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**TRANSACTIONS OF
THE ROYAL SOCIETY
OF SOUTH AUSTRALIA**

INCORPORATED

ADELAIDE

**PUBLISHED AND SOLD AT THE SOCIETY'S ROOMS
KINTORE AVENUE, ADELAIDE**

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ABORIGINAL CRAYON DRAWINGS IV RELATING TO EVERY-DAY INCIDENTS OF THE NGADA TRIBE OF THE WARBURTON RANGES OF WESTERN AUSTRALIA

By C. P. Mountford, Acting Ethnologist, South Australian Museum

Summary

While attached to the 1935 Adelaide University Anthropological Expedition to the Warburton Ranges of Western Australia,⁽¹⁾ a number of sheets of crayon drawings were obtained, the work of the aborigines of those parts. The method of collecting was explained in a previous paper (Mountford, 1937), considerable care being taken not to influence the natives in the choice of either the subject or of the colours employed. Most of the drawings obtained related to the exploits and wanderings of the aborigines' mythical ancestors. They were secret in character and not seen by either the women or the uninitiated youths. Two such suites dealing with human totemic ancestors have already been described (Mountford, 1937 and 1938). The drawings described in the present series deal only with the incidents and objects of the daily life of the aborigines, and are not associated with the ceremonial life.

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ABORIGINAL CRAYON DRAWINGS IV

RELATING TO EVERY-DAY INCIDENTS OF THE NGADA TRIBE OF THE WARBURTON RANGES OF WESTERN AUSTRALIA

By C. P. Mountford, Acting Ethnologist, South Australian Museum

PLATE I

[Read 13 April 1939]

While attached to the 1935 Adelaide University Anthropological Expedition to the Warburton Ranges of Western Australia,⁽¹⁾ a number of sheets of crayon drawings were obtained, the work of the aborigines of those parts. The method of collecting was explained in a previous paper (Mountford, 1937), considerable care being taken not to influence the natives in the choice of either the subject or of the colours employed. Most of the drawings obtained related to the exploits and wanderings of the aborigines' mythical ancestors. They were secret in character and not seen by either the women or the uninitiated youths. Two such suites dealing with human totemic ancestors have already been described (Mountford, 1937 and 1938). The drawings described in the present series deal only with the incidents and objects of the daily life of the aborigines, and are not associated with the ceremonial life.

In order to ensure accuracy, the drawings were traced and reduced to publication size by the printer. The colours are represented diagrammatically on each sheet.

DESCRIPTION

Fig. 1 was drawn by an elderly aborigine named Tolaru and represents the camps of four men and their families. II and J are paths from the various camps to a waterhole A, on which these people depend for their supplies. B is the windbreak of one of the camps behind which the whole family sleep. C is a man (*wati*), E and D two women (*mima*), and F a small child (*tjitji*). Fires are shown either side of E, C, D and on the left-hand side of F. The parallel lines to the left of K, at N, and to the right of M, represent the spare sticks of firewood laid in readiness to replenish the fire during the night.

O is the windbreak and camp of another family. The crescent-shaped marks indicate the couple sleeping between fires *waru*—shown as circles on either side. P is the man.

⁽¹⁾ This expedition was partly financed by funds from the Rockefeller Foundation and administered by the National Research Council.

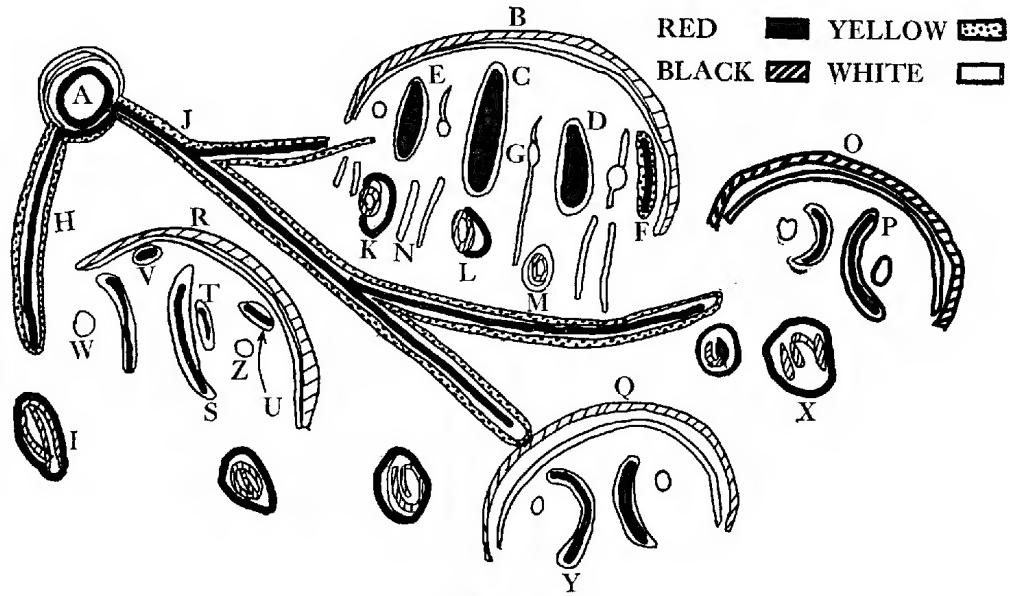


Fig. 1

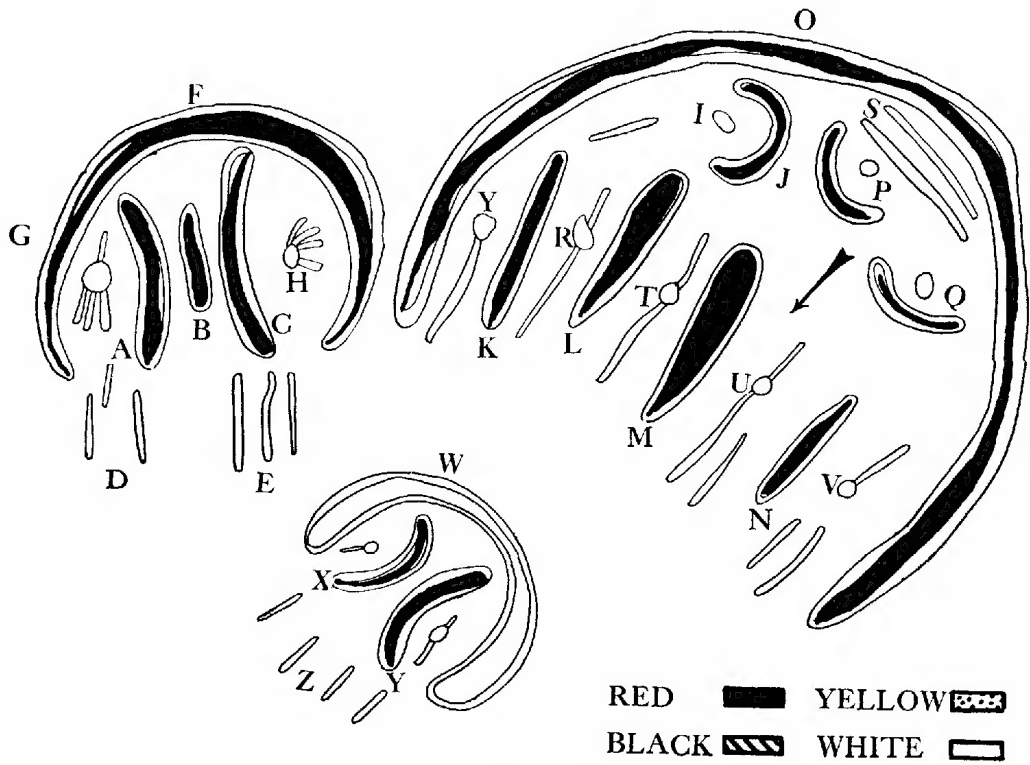


Fig. 2

A flashlight photograph of a similar scene from the same locality is shown in pl. i, fig. 1; in this the windbreak, the placing of the fires and particularly the sleeping position of the children are well shown, and it is easy to understand, when the pose of the sleeping children is noted, how a crescent-shaped mark is used to indicate a person sleeping at night.

The camp at Q is similar to that at O; Y is the male. R is the camp of a man, his wife and two children. S indicates the former, who, with his two children T and U, are grouped around a fire, Z. The other fire, W, is to the left of the woman. V is a spear-thrower (*langguru*). These and the spears are usually stuck in the windbreak for safe keeping. K, L, M, X, I and similar designs are indicative of ovens where rabbits (*nani nani*) had been cooked.

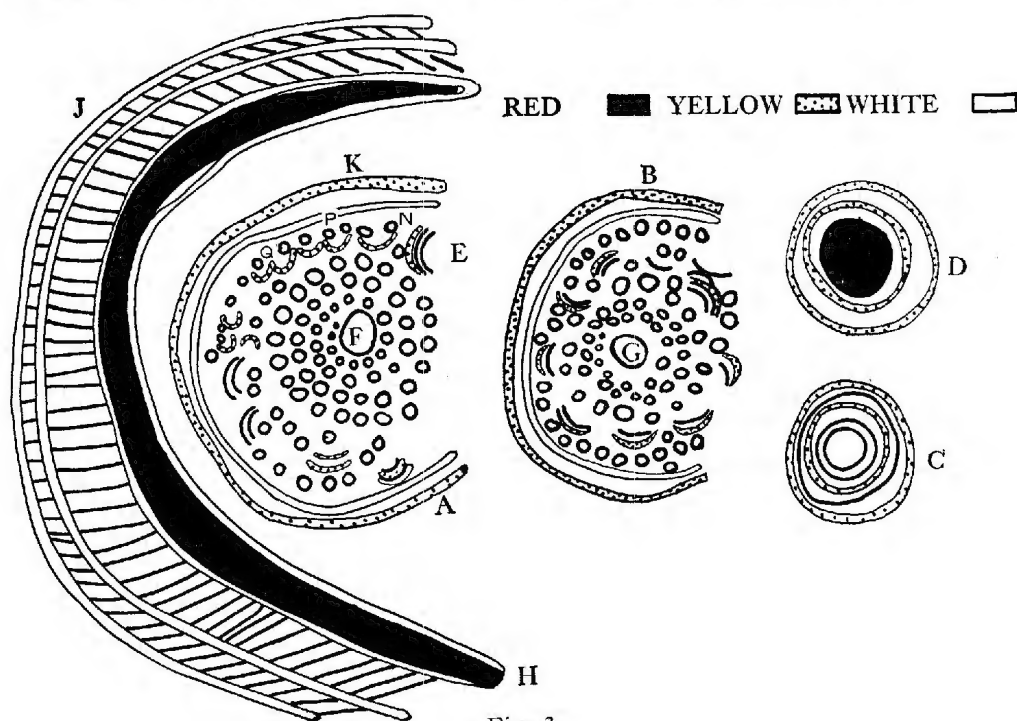


Fig. 3

In the Ngada tribe the families occupy separate camps, often no more than a few yards apart, while the single men, separated by fires and protected by a windbreak, sleep in a long row. Such a camp is depicted by old Tolaru in fig. 2. Four men are shown, K, L, M, N, sleeping between the fires Y, R, T, U, and V. Uninitiated and uncircumcised boys,⁽²⁾ J, P and Q, are shown beside their own fires. O is the windbreak. The straight lines across Y, R, T, and so on, are the logs of wood of which the fire is composed. As the wind would blow in the direction of the arrow, the log on the leeward of the fire would burn more quickly

⁽²⁾ At the first signs of puberty, the boys are ceremonially driven from their mothers' camp and forced to sleep by themselves, often some distance away from the main camp. During this time they have no association whatever with the women.

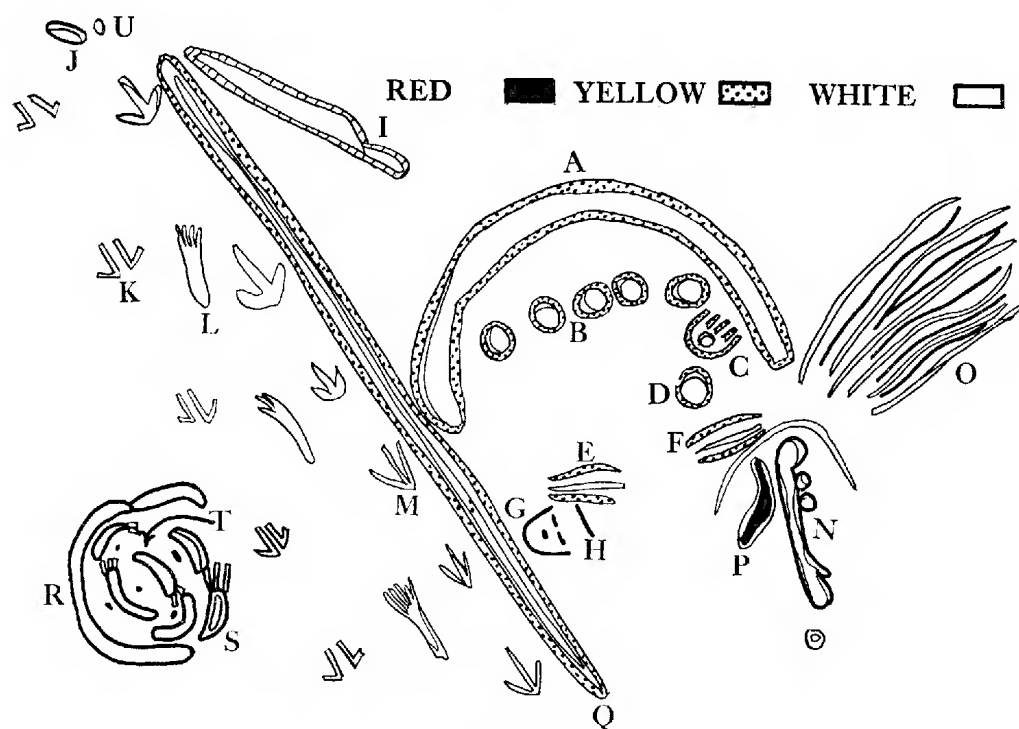


Fig. 4

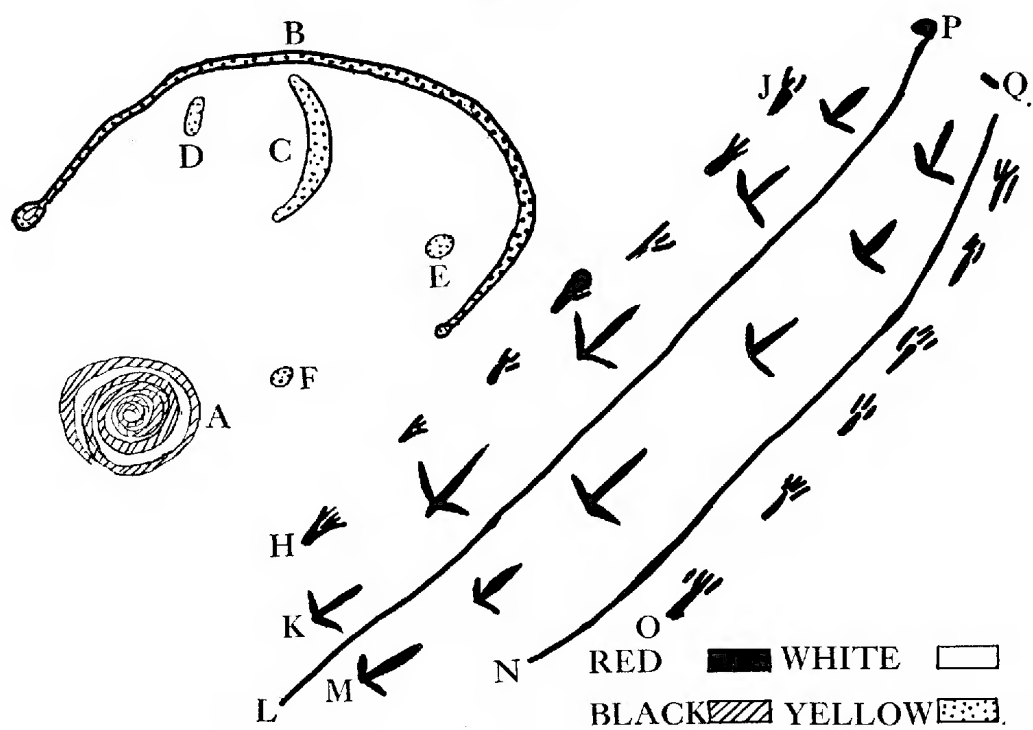


Fig. 5

than that on the other side. The aborigine has indicated this characteristic by placing the longer line on the leeward side. S are spears, laid in the windbreak for safe keeping.

F is the windbreak of a camp of a married man, his wife and his child. An attempt has been made by the artist to sketch a wet-weather camp, which is roofed over in a crude manner with the branches of trees. A is the woman, C the man, and B a child. Spare wood to replenish the fire is indicated at D and E. W is another married man's camp, the meanings of the respective symbols being similar to F.

WHITE ☐ YELLOW ☒

BLACK ☒

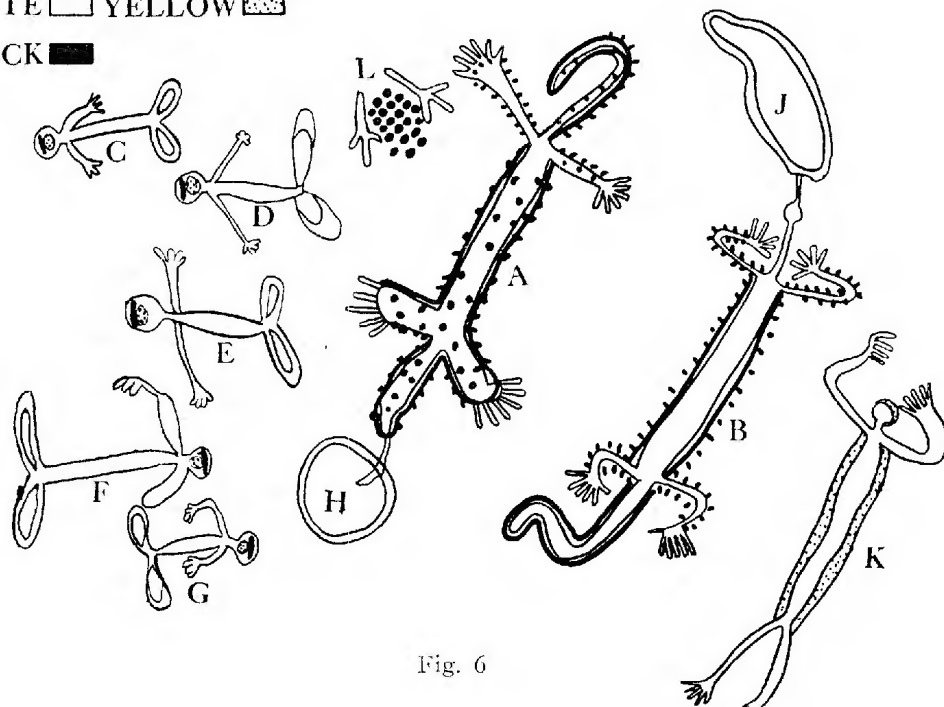


Fig. 6

Fig. 3, drawn by Mungalo, represents two wet-weather camps (*wiltja*). The walls of the shelter are indicated at K and B, the fires at F and G, and the water-holes at C and D. The circles are aborigines sitting around the central fires, and the crescents those who are asleep beside their small fires (indicated as small circles, i.e., N, P, and Q). H and J are primary and secondary rainbows.

A considerable amount of symbolism is evident in this drawing. In the first place, about ninety individuals are seated around the central fire F, and seventy at G. Five or six would be the largest number that could be squeezed into a wet-weather shelter, and even then conditions would be uncomfortable. It is likely that the crowding together of people had so impressed the artist that he endeavoured to represent this feeling by indicating a large number of people, far more than could possibly have occupied such a shelter.

Again the aborigine had no means of differentiating between a wet and a dry season camp. To draw one in side elevation was beyond him, and the plan view of both types were similar. For that reason, it seems likely that he added the rainbow II to indicate rain or stormy weather. The addition of the secondary bow, J, was a further example of his artistry.

On fig. 4 is again depicted a wet weather camp, R. Here the crowding is shown more realistically than in fig. 3. Six natives, S, T, etc., are sleeping around the fires (shown as dots).

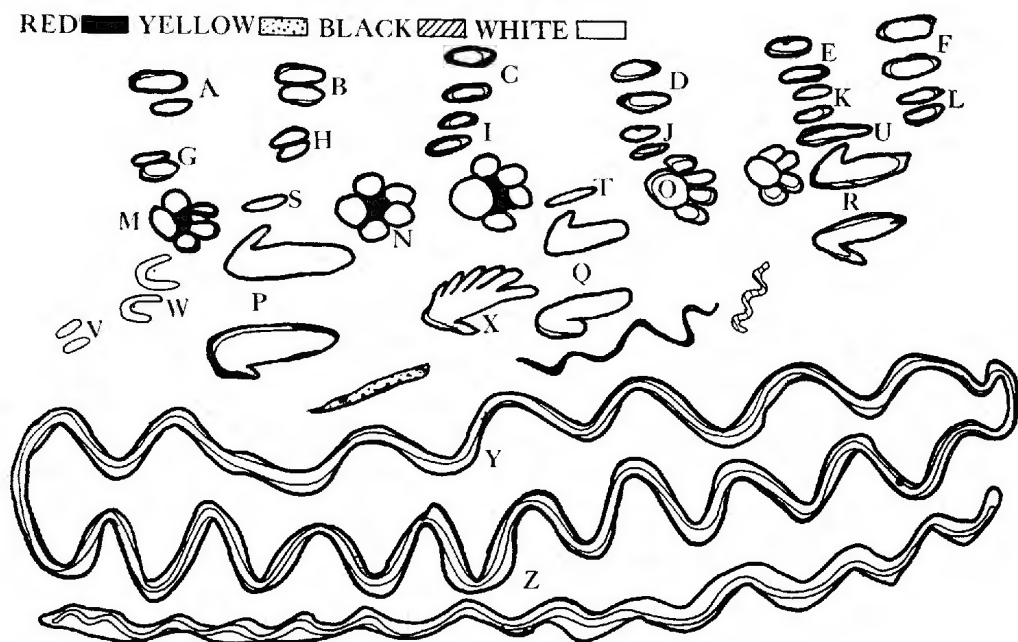


Fig. 7

On the right of R is an aboriginal story of a hunt. The paired tracks, K, are those of a kangaroo which the artist saw but did not chase. He was successful, however, in spearing an emu, which ran some distance (tracks M), still dragging the spear (see Q). The artist chased the emu (line of tracks, L), and caught and cooked it at U and J, respectively. I is the spear-thrower, which was left behind after the hunter had killed the emu.

On the right-hand side of the same drawing is a scene that depicts the cooking of a kangaroo and the distribution of the flesh. The marks within the crescent at G indicate three men who have buried a kangaroo in a cooking oven, H, and are waiting for it to be cooked.⁽³⁾ Five men, B, seated behind a windbreak, A,

⁽³⁾ The method of cooking the kangaroo is as follows: A trench about four feet long, eighteen inches wide, and a foot deep is dug and a fire lit on top. When this has burned down the kangaroo is laid, feet upwards, in the trench and partly covered with the hot sand and ashes for from thirty to forty minutes (pl. i, fig. 2), as can be seen in the photograph. At the best, it is only partly cooked.

await the distribution of the meat. D is an unspecified individual, and C an unknown symbol. E and F are trenches where kangaroos had been cooked previously. O are the spears of the men waiting behind the windbreak at A. A man and a young girl (*kunka*), P and N, are shown lying down behind a windbreak. This drawing was produced by Pinkari, a particularly intelligent aborigine about twenty-five years of age.

Another illustration of a hunt, fig. 5, was made by Njilpiri. Two men, whose tracks are depicted at H and O, both speared an emu apiece. The dragging spear and the footprints of the wounded emus are drawn at K, L, M, N. The emus were caught and cooked in the ovens at P and Q.

B is the camp in which a young unmarried woman C, is asleep between fires D, E, and F. A is a hill (*jabu*).

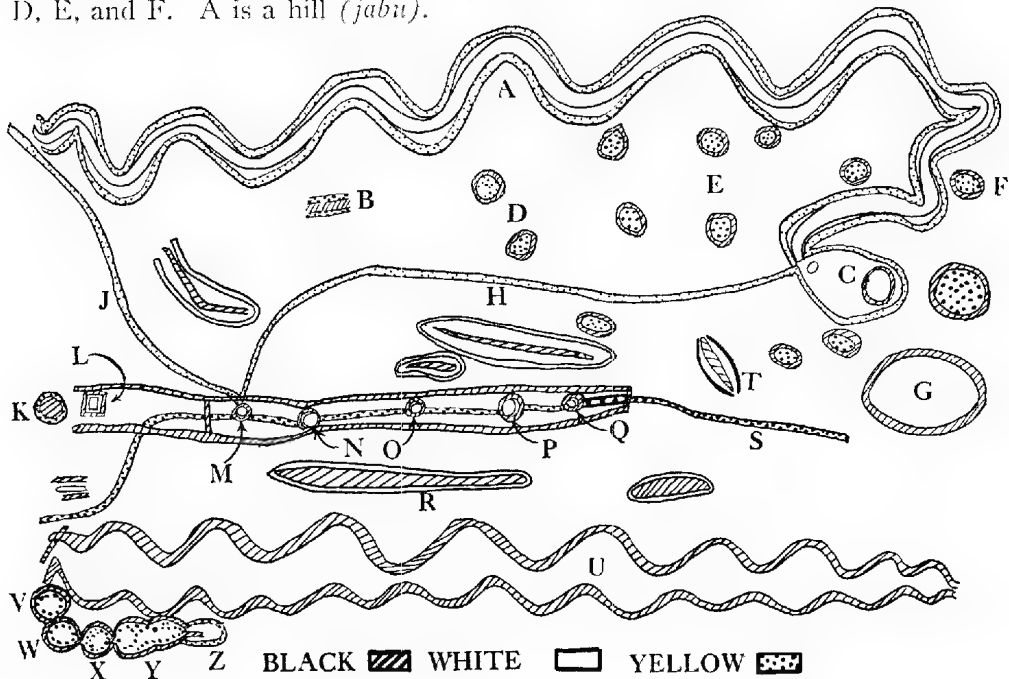


Fig. 8

Fig. 6 was drawn by old Mungalo and relates to a time when he chased a perentie⁽⁴⁾ into its hole, H, captured, cooked and ate it. Both A and B refer to the same lizard. The line from the head of the lizard to the hole indicates the track taken by the perentie which, when Mungalo saw it, had just come out of its burrow to sun itself. The large spots on the body of the reptile are indicated by black dots. The artist indicated himself as standing up at K, having a rest after having eaten his meal.

C, D, E, F and G are five men seated on the ground. They do not appear to have had any connection with the catching of the lizard.

⁽⁴⁾ This is a large lizard, often over seven feet in length, commonly known as the Perentie (*Varanus giganteus*); the aboriginal name is *ngintaka*.

L is an excellent representation of a nesting emu. The black spots are the eggs and the outer symbols the marks made by the feet and lower part of the leg. Spencer and Gillen (1899, fig. 124) figure a similar design from the George Gill Range of Central Australia.

Fig. 7 pictures a number of tracks seen by Nalkeinga, a dwari, whilst on a journey. A, B, C are the tracks of Nurlu, one of the indigenous marsupials (see Mountford, 1938, N, G, II, O, R, fig. 2). G, H, I, D, E, F are the tracks of an unidentified hopping marsupial called *kurluari*. A story of a speared kangaroo pursued by a dog is next depicted. N, O are the tracks of the dog,

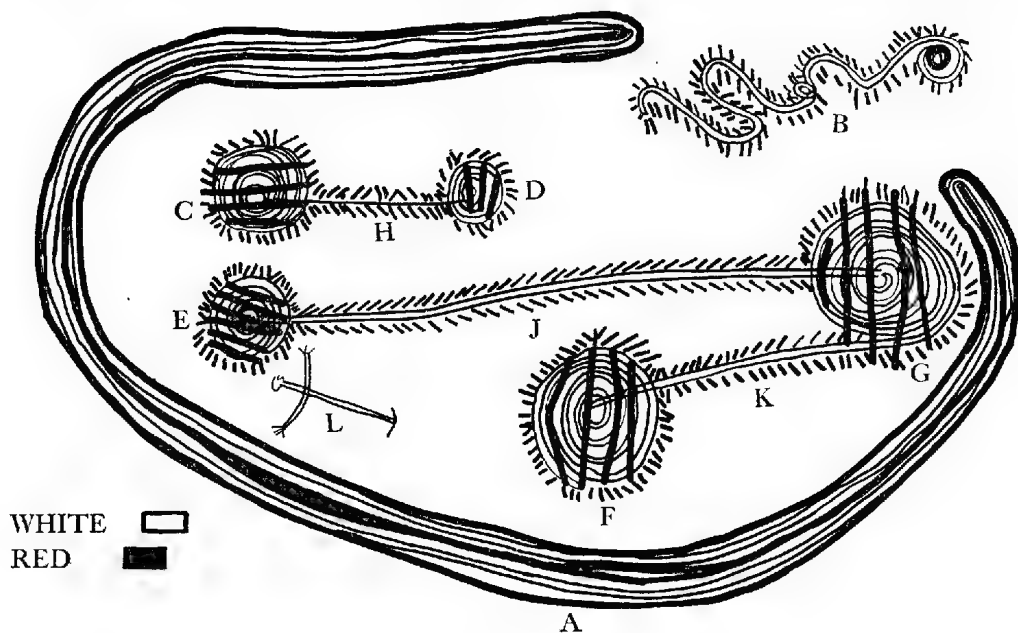


Fig. 9

S, T, U the mark made on the ground by the dragging spear, and P, Q, R the footprints of the wounded kangaroo. X is a track of a perentie, W the marks made by a little snake, and V those of Nurlu (see A, B, etc.). Y and Z are symbolized figures representing a poisonous snake (*leiru*) and a smaller snake lying down in sandhill country.

Fig. 8, the work of a man about twenty-five named Pinkiri (see fig. 4), is, in reality, a geographical map of the country adjacent to Kahnga soak.⁽⁵⁾ A is a watercourse; the transformed track of the carpet snake (*wanambi*) who travelled to and created Kapi Walguta (C), (*kapi*-water). A number of low hills are also marked, some as circles, some as ovals, i.e., D, E, F, R, T, and G. J, H, and S are native tracks leading to various waterholes, L, M, N, O, P and Q, which are situated in a creek that flows from the adjacent ranges. K is a gum

⁽⁵⁾ Shown on Western Australian map IX/800 between PB 330 and PB 335 and adjacent to Mount Elsie. This locality was about 45 miles due east of our base camp on the junction of the Elder and Warburton Creeks.

tree (*tuata*), and I. Kahnga soak. When the artist was asked why he indicated this waterhole with a square (an unusual aboriginal symbol), he explained that some white men had made it that shape. On noticing, also, that the native track led to waterhole M, instead of L, which, having been deepened, would possibly be the more permanent water supply, the artist gave as his reason that the natives had always drank at M, even before the white man came.

The lower part of fig. 8 relates to the time when the artist chased a carpet snake (*kurneia*) until it entered its burrow at V. Pinkiri dug holes at W, X and Y in his efforts to obtain his prey, and finally, in the last hole, Z captured the snake. It will be noticed that the track of the snake is drawn in duplicate. This is not uncommon in aboriginal crayon drawings (see A and B, fig. 6).

Fig. 9, drawn by Tolaru, illustrates the tracks and holes of a centipede, (*kanbulga*) which were adjacent to a termite mound. C and D, the openings

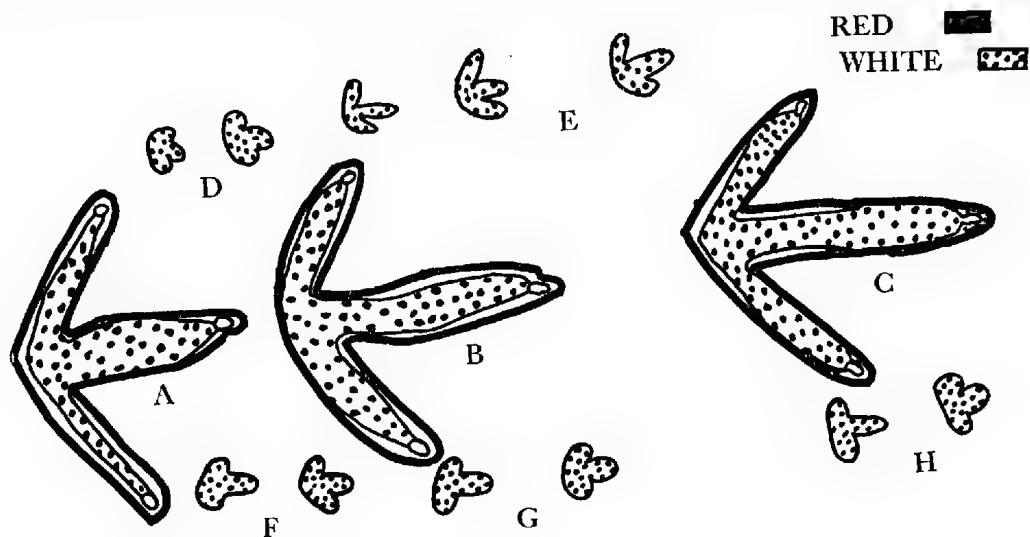


Fig. 10

of two such burrows, are connected by a centipede track. B is a drawing of the same animal, the many legs being well represented. E, F, G are three more holes, J, K, the tracks made by the insect as it travelled from one opening to another. L is a small lizard, and the incomplete ellipse, A, a termite mound. From the shape of A it would appear that the bulk of the mound had weathered away.

Fig. 10, also the work of Tolaru, illustrates the footprints of a male emu and the chicks as they walked across the sandy country. A, B, C are the tracks of the male parent, and the upper and lower lines of footprints D, E, and F, G, H those of the young chicks.

Fig. 11 was drawn by a middle aged native, Jandjibalana, and depicts incidents in his journeys across parallel lines of sandhills which were situated to the north-east of our camp. The lines, such as Q, R, S, T and U, indicate those sandhills

(*tali*), and L, M, N, O and P the spinifex covered flats (*bila*) between them. While Jandjibalana was at A, an unspecified waterhole, a white man with a camel arrived, stayed for a while and left for E, Kapi Purkana. He then travelled to B, camped for a while, and returned by the same track as he came, *i.e.*, the black line, G. C is a tree close to the white man's camp. Jandjibalana, himself, came into the sandhill country by track K, camped at V, which is adjacent to a waterhole, Kapi Bunabulgun, and then travelled through G, an unspecified locality, to his camp F in the sandhills, near Kapi Purkana, E.

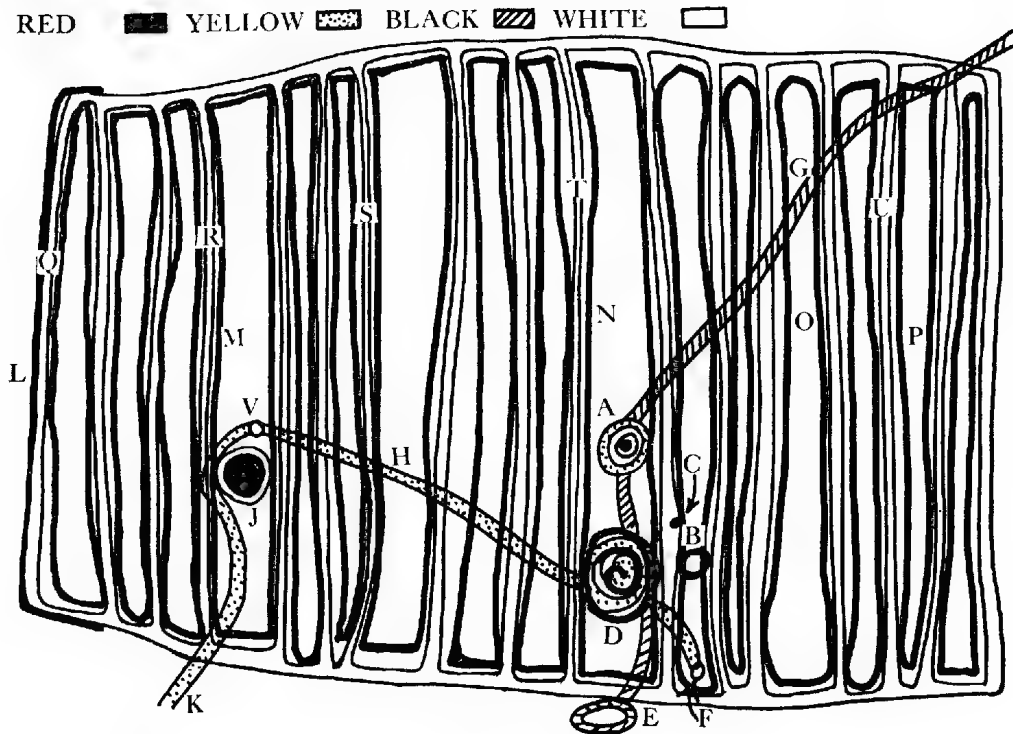


Fig. 11

DISCUSSION

The drawings of this suite are of particular interest because they depict the every-day things in an aboriginal community, their camps, their travels and the incidents of the hunt. There was no secrecy attached to them, nor any mythological story such as was associated with the majority of the other drawings obtained. Several points are worthy of note:—

- (1) The aborigines, almost without exception, drew all objects in plan view. This is well illustrated in the depicting of aboriginal camping places (see figs. 1, 2 and 3), in the story of the hunt (figs. 4 and 5), various tracks (figs. 7, 9 and 10), and natural features (fig. 8). The exceptions are on fig. 6, where Mungalo drew, in side elevation, five men seated, and himself standing up. In the same sheet, however, he depicted the perentie, its

track and its burrow in plan, as well as the interesting illustration of a nesting emu. Mungalo, however, showed more skill and artistry in his drawings than did the other men, and some of the most decorative examples obtained on the whole expedition were his work (see Mountford, 1937, fig. 1).

- (2) It was also noticeable that all animals were indicated by their footmarks. Kangaroo-like creatures are pictured as in K, fig. 4; snakes as a meandering line, A, fig. 8; and in general human beings by the footprints only, L, fig. 4, and H, fig. 5. The same characteristic is noticeable in the rock carvings of South Australia (Mountford, 1928, p. 348).
- (3) Another point worthy of note is the amount of detail in some of the drawings, *i.e.*, the method of placing the longer piece of wood on the lee side of the fire (figs. 1 and 2), the double rainbow (fig. 3), and the water-hole depicted as a square because a white man had made it that way.

The obvious ease with which the natives produced the primitive symbols on the sheets of paper indicated that, at other times, similar drawings had been made on a different medium. Careful enquiries among the natives of various tribes failed to reveal any information on this point, but as rock paintings are rare, and carvings, as far as is known, non-existent in this area, the most obvious "drawing board" for the native artist would be the sandy surfaces of the ground. Recently Mr. Maurice Radford, of Canegrass Station, told me that on a number of occasions, both in Central Australia and on the Birdsville track, he has seen groups of natives sitting around a smoothed-out patch of sand, and one of them making drawings on the surface with a stick, explaining meanwhile to his companions the significance of the drawings. His place would then be taken by another man, who, in turn, would illustrate some incident by the same means. Mr. Radford mentioned that he has seen men sit for hours entertaining or instructing others in this manner.

It seems possible that here we have an explanation of the aborigines' ease in drawing with the crayons, for it was noticeable that the natives, after a few tentative strokes with the crayons on the brown paper supplied (to him only another medium), made the drawings with ease and confidence.

SUMMARY

This paper records eleven sheets of aboriginal crayon drawings produced by men of the Ngada tribe of the Warburton Ranges of Western Australia. The drawings, which deal with every-day objects and incidents are described and discussed.

LITERATURE

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 MOUNTFORD, C. P. 1937 Records S. Aust. Museum, 6, (1)
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 SPENCER and GILLEN 1899 Native Tribes of Central Australia



Fig. 1 Camp scene of Ngada tribe, showing disposition of fires, windbreak and sleeping position of children



Fig. 2 Kangaroo cooking in native oven, Ngada tribe

THE GEOLOGY OF THE CAPE SPENCER AREA, YORKE PENINSULA

By J. O. G. GLASTONBURY, B.A., M.Sc., Dip.Ed.

Summary

Although the main outlines of the geology of this area have already been worked out by Greenway and Phillips (1) and R. Lockhart Jack (2), there are several points of detail of considerable interest not dealt with by these writers, and it is the purpose of this paper to record them. These earlier writers have recorded formations of Recent, Pleistocene and Pre-Cambrian (Archeozoic) age in this area; but as Howchin and David believe that similar consolidated sand dunes to those that Greenway and Phillips refer to as Pleistocene age are Recent, those found in this area will be taken in this paper as Recent.

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By J. O. G. GLASTONBURY, B.A., M.Sc., Dip.Ed.

[Read 13 April 1939]

INTRODUCTION

Although the main outlines of the geology of this area have already been worked out by Greenway and Phillips (1) and R. Lockhart Jack (2), there are several points of detail of considerable interest not dealt with by these writers, and it is the purpose of this paper to record them. These earlier writers have recorded formations of Recent, Pleistocene and Pre-Cambrian (Archeozoic) age in this area; but as Howchin and David believe that similar consolidated sand-dunes to those that Greenway and Phillips refer to as Pleistocene age are Recent, those found in this area will be taken in this paper as Recent.

RECENT

Little need be said in addition to what Jack has stated about the gypsum and salt deposits of this area. The mode of formation of these, the most recent formations on Yorke Peninsula, is clearly desiccation of a marine area held back by a bar of land of some kind. The periodical nature of the desiccation is revealed by alternations of thin bands of calcium carbonate with those of the gypsum. These alternations are found in the rock gypsum deposits, which are from three to six feet in thickness and underlie overburden which is from two to three feet thick and is composed of "seed" gypsum and fine calcium carbonate. Organic matter, including plant remains and humus, underlies the main gypsum deposits. These organic remains and the presence of certain marine fossils give no room for doubting that this portion of Yorke Peninsula has suffered a recent uplift of some feet. Corroboration of this is received by the presence of raised sea beaches along parts of the western coast of the Peninsula, Pondalowie Bay being a particularly good example. Of interest in this connection is the presence of Recent marine fossiliferous limestone overlying a very small area of a metamorphic doleritic intrusion at Cape Spencer. This particular deposit, although now of very small superficial extent, is worthy of mention because its present altitude (some ten to twelve feet above sea level) shows that here, too, there is still preserved evidence of land elevation.

Greenway and Phillips refer to 300 feet high cliffs composed of calciferous sandstone, but which are very likely consolidated sand-dunes. This is all the more probable, because they are capped in places by sand-dunes which are frequently separated by flat areas up to 100 square yards in area and composed of travertine limestone. More compact travertine limestone, which frequently has a strongly developed nodular character, is found at various levels in the cliffs. This feature is particularly noticeable a little to the east of Cape Spencer itself and extends as far east as Rhino Head. It is quite possible that these layers of

travertine represent a series of land levels when the general elevation of the region was at a standstill. Greenway and Phillips mention bands of clay, one to two feet thick, lenticular in shape, which are intercalated between the main beds of calciferous sandstone. The width of these clay bands, which show marked current bedding, however, often exceeds two feet, and, indeed, sometimes reaches as much as five feet. Common to the upper layers of the sandstones is the presence of remarkable sandy calciferous root-like structures. Occasionally structures of this kind are seen in close contiguity with actual plant roots which are still unaltered. These structures appear to be calciferous infillings of holes which once were occupied by the roots of plants. Not only have small roots given rise to such structures but more rarely tree trunks also have apparently fulfilled this function, for, in places, similar casts up to ten inches in diameter, and some three to four feet high, have been found.

MIocene AND PERMO-CARBONIFEROUS

No occurrence of rocks of these ages was found in this area, although both are largely developed elsewhere on the Peninsula.

PRE-CAMBRIAN (ACHEOZOIC)

In the small bay to the immediate east of Cape Spencer occur small wave-cut terraces in the Pre-Cambrian rocks.

These Pre-Cambrian rocks are the most interesting feature of the Cape Spencer area. The lower levels of the most southerly part of the Cape consist of rounded masses of granitoid gneiss, jointed, foliated and in places contorted. This gneiss continues in a westerly direction and, indeed, is the most abundant of all the crystalline rocks of the area. A more detailed petrological examination shows it to be a light-grey foliated rock on which bands rich in biotite ($\frac{1}{4}$ mm. to $\frac{1}{2}$ mm. wide) alternate with bands of quartz and felspar. In places there is local concentration of the biotite bands and the rock assumes a slightly darker hue. Both the felspar and quartz are light coloured; the felspar is cloudy and slightly pitted because of weathering effects, and the quartz for similar reasons tends to be saccharoidal and to develop a reddish colour causing some grains to look not unlike garnet. Under the microscope the leucocratic minerals are seen to be microcline, microcline-micropertthite, albite (about $\text{Ab}_{90}\text{An}_{10}$), anti-perthite and quartz. The latter is in minor proportion to the felspars. It is not particularly clear, and is usually free from cracks, but exhibits undulose extinction. Myrmekitic inter-growths of quartz and felspar are not uncommon. The other essential mineral is biotite. It is markedly pleochroic and shows a strong absorption. The absorption formula is $Z > Y > X$, where Z is deep bottle green, Y pale bottle green, X pale straw colour. The accessory minerals are important in that they show the igneous origin of the rock, that is, they enable one to be certain that the rock is an ortho-gneiss. These accessory minerals are apatite, zircon and epidote which tends towards allanite, the cerium-bearing form of this mineral. In a few grains the typical zoning which characterises allanite is seen—the central portion bright orange in colour, the outer

regions much more drab. A little haematite and a few grains of magnetite are also present. These gneisses are cut by veins ($\frac{1}{4}$ in. to 6 in. thick) of aplitic and pegmatitic material. The minerals of the pegmatite are quartz and feldspar.

In this southernmost part of the Cape are found dykes of a fine red metamorphosed aplitic rock intruded into the gneiss. The aplite, like the gneiss, is jointed and weathered, spheroidal weathering in part, at least, having occurred. Of interest is the occurrence of two pot-holes in this rock, one being about ten feet deep, the other about six feet, which were formed by the swirling action of the waves.

In places a localized grey variety of the aplite is found. Macroscopically it is seen to consist of small white feldspar crystals (up to 2 mm. long), grains of quartz of about the same size and small flecks of black mica. Microscopically, the feldspar is identified as microcline and microcline-micropertlite. The quartz is clear but shows undulose extinction. The biotite is much darker than in the gneiss described above. It has suffered alteration to some extent, chlorite having developed along fibres as well as peripherally. Some of the prisms of biotite have completely altered to this pale green mineral of low birefringence. The biotite holds as inclusions the following minerals; zircon which serves as nuclei of pleochroic halos, apatite and magnetite. The last two minerals also occur throughout the rock as discrete grains. The more common form of the aplite is the red one which is not very different from the other one in the hand-specimen, but is slightly finer grained and with marked secondary changes in the biotite.

About 40 yards west of the area just described are found two circular masses of dark igneous rock which Greenway and Phillips referred to as dolerite, a very convenient field term, but one which does not adequately describe the present rock which is a hornblende-plagioclase-schist. These circular masses are about 50 feet across and are separated by a neck of the gneiss, which is here crossed by a 1-foot wide pegmatitic vein. The basic rock definitely intrudes the gneiss and is, in turn, crossed by stringers of quartz. It is cracked and jointed, and in places rude columnar jointing is evident. Where the veneer of recent calcareous marine material has but lately been removed honey-comb weathering of the surface has proceeded. Macroscopically this is a lustrous melanocratic rock in which shining crystals of black hornblende and dull white plagioclase are seen. Here and there are light brown circular masses from 1 mm. to 6 mm. in diameter.

Microscopically the hornblende is seen to be pleochroic in greens and very pale yellow. It shows marked absorption with $Z > Y > X$ where Z is deep in bottle green, Y lighter green, X straw colour. The feldspar is albite-oligoclase. The light brown zones are seen in the microscope section to contain practically no hornblende, but sphene and magnetite are very common; feldspar also occurs.

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ABORIGINAL ARRANGEMENTS OF STONES IN CENTRAL AUSTRALIA

By T. D. CAMPBELL and C. P. MOUNTFORD

Summary

The following notes and illustrations were recorded during the journey of the Leichhardt Search Party in August, 1938. The opportunities for intensive ethnological studies were necessarily limited owing to the main purpose and nature of the journey; but the subject matter of those cursory notes is considered of sufficient interest to justify placing them on record.

ABORIGINAL ARRANGEMENTS OF STONES IN CENTRAL AUSTRALIA

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[Read 13 April 1939]

PLATE II

The following notes and illustrations were recorded during the journey of the Leichhardt Search Party in August, 1938. The opportunities for intensive ethnological studies were necessarily limited owing to the main purpose and nature of the journey; but the subject matter of those cursory notes is considered of sufficient interest to justify placing them on record.

Occurrences of aboriginal stone arrangements have been recorded by several writers. Wood Jones (1925, p. 123) describes one on Gungra claypan about a hundred miles north of Kingoonya; Dow (1938, p. 126) several from the West Darling districts; Elkin (1938) illustrates one which relates to a yam ancestor, and Love (1938) describes many from North-Western Australia.

A striking feature of interest concerning the present examples is that they occur right in the midst of thickly-strewn gibber areas; so that, unless actually sought out from previous description, or traversed by one on the look-out for aboriginal relics, they might easily be passed unnoticed owing to their close association with such an abundance of surrounding gibber material.

The occurrences recorded here are situated not far from the south-west margin of the Simpson Desert, a few miles south of the South Australian-Northern Territory border, and about eighty miles due east of Abminga on the Alice Springs railway line. The sketch map in fig. 1 illustrates a few points concerning the location and associated features of these aboriginal relics.

While some of the designs are still intact enough to present striking arrangements of varying-sized boulders, others have become disintegrated and the original alignments of the stones have been lost among the profusely strewn and scattered gibbers which lie on these slightly elevated areas.

The following notes and diagrams will serve to describe a few of the more striking occurrences which the authors were able to examine during a hurried motor journey. The letters on the sketch (fig. 1) indicate the position of the various examples and the sequence of the following descriptions.

GROUP A

A fairly well defined and somewhat curved line of stones about twenty yards in length, formed of irregular-shaped boulders about nine to twelve inches in diameter. Probably a remnant of a more extensive figure.

GROUP B

Another line for which the description given for No. 1 also serves.

GROUP C

The observed portions of this group occupied an area of roughly about four hundred yards by two hundred. The main features diagrammatically sketched in fig. 2 represent only the more intact portions of a striking display; and it is felt from our general observations of these finds, that in this instance time had permitted us to discover only portions of an extensive group of designs. The more intact arrangements were:—(a) A long U irregular-shaped figure of

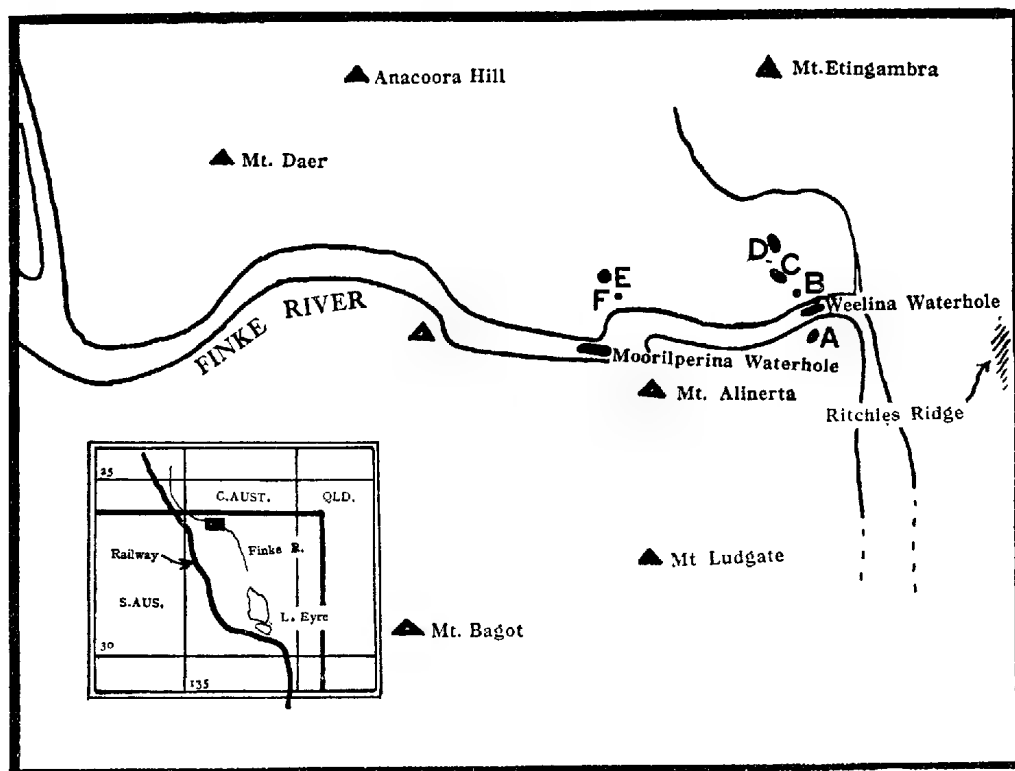


Fig. 1

arranged boulders, varying in diameter from twelve to eighteen inches; at the ends of this curve were two partly collapsed piles, each about three feet in diameter (fig. 1, pl. ii). About twenty yards away were two well-defined parallel lines (b). About a similar distance to the east of the U design was a striking irregular group (c) of large, flattish, rectangular boulders which had been placed in the ground endwise; standing up like an imposing collection of monoliths, each about two to three feet in height.⁽¹⁾

⁽¹⁾ Love, 1938, figures a similar group in the Worora territory of North-West Australia. In this case they are associated with a wrestling match between kangaroo ancestors.

Approximately a hundred yards to the west of these were further arrangements (d), the most obvious of which was a fairly intact pile of large stones forming a cairn about ten feet in diameter and three feet six inches in height (fig. 2, pl. ii). Nearby this pile were also a number of small-sized oval and circular arrangements, most of which had been disturbed by scattering of their constituent stones.

GROUP D

About half-a-mile to the north of group C and near the edge of the same gibber rise, we passed a number of small, somewhat disintegrated designs; most of these appeared to be circular or oval in shape; the latter being about twelve yards on their longer and five yards in the shorter axes.

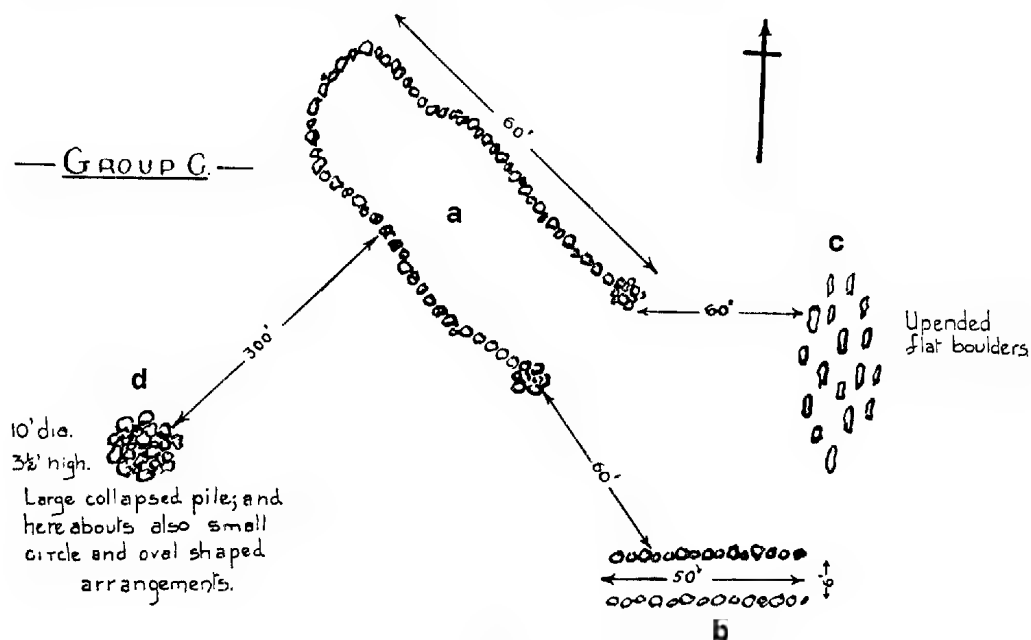


Fig. 2

GROUP E

About a mile east of Moorilperina Waterhole, on the edge of a low extensive gibber rise, we observed another group of designs (fig. 3), which again seemed as if they might be only a portion of a widely distributed group. On the whole, these particular figures were formed of definitely smaller stones than those designs already mentioned; and on this account were less easily detected among the myriads of gibbers which surrounded them. (a) consists of a long winding line of varying-sized boulders, a few of which might be twelve inches in diameter. One end of this line is lost among the adjacent stones, the other end sharply curves at nearly a right angle. Figures b, c and d are somewhat irregularly oval in contour, all about the same dimensions; (c) was rather incomplete;

(d) had a small circle of about two feet diameter associated with it; while (b) had an inner line, and three small heaps at its eastern end.

GROUP F

About 40-50 yards away to the south of the above groups was a series of more or less collapsed piles of varying sizes. There were vague indications that these may have been connected up by a continuous line. Most of these piles were of rough stones about nine to twelve inches in diameter.

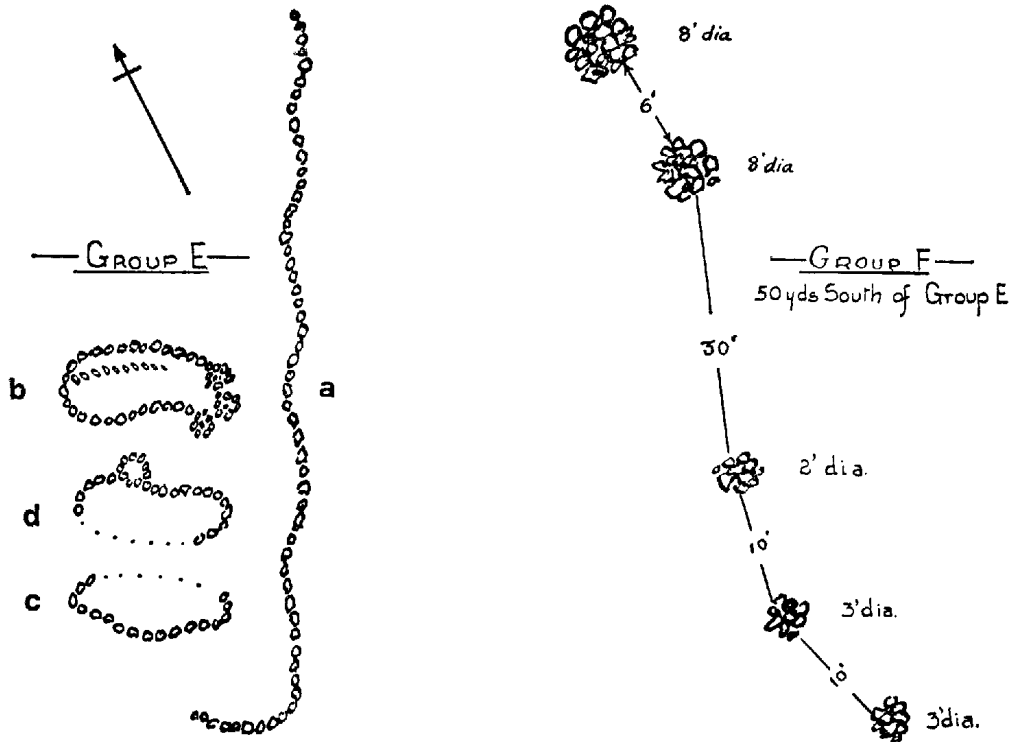


Fig. 3

In addition to the above designs of group E there were many other fragmentary, but, nevertheless, definite indications of other designs which obviously had helped to form another major and widespread group of figures.

One of the authors (C. P. M.) was able to obtain information from the aborigines of these parts regarding the use and mythology of these arrangements. The groups at Weelina Waterhole, A, B, C and D, were associated with a carpet snake ancestor. This mythical being travelled over the country and, during his journeyings, made the Weelina Waterhole on the Finke River. At certain seasons of the year members of the snake totem would assemble and perform ceremonies for the increase of carpet snakes. Such rituals were carried out on these sites.



Fig. 1 Arranged stones, Weelina



Fig. 2 Stone Cairn, Weelina

The group at Moorilperina is also considered to be of mythical origin. The natives believe that the stone arrangements were made by one of their human "dream time" ancestors, when travelling with his family from the south to the north.

The aborigines to whom this country belongs are members of the southern Aranda group. They are sadly diminished in numbers and, no doubt in a few years, all opportunity for acquiring information regarding these people will have vanished for ever.

SUMMARY

This paper briefly discusses some unrecorded groups of aboriginal arrangements of stones. They occur near the Weelina and at Mooliperina Waterholes on the Finke River, in the northernmost part of South Australia.

Their arrangements are briefly described, and mythology discussed.

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ABORIGINAL NAMES AND USES OF PLANTS AT THE GRANITES, CENTRAL AUSTRALIA

By J. B. CLELAND, M.D., and T. HARVEY JOHNSTON, M.A., D.Sc.

Summary

During the course of the expedition organised by the Board for Anthropological Research of the University of Adelaide and the South Australian Museum in August, 1936, to the Granites (native name, Boorkitji), nearly four hundred miles north-west of Alice Springs, the native names and uses of as many plants as possible were obtained, and are here recorded. The tribe inhabiting the region is termed Wilpirri. We are indebted to the Rockefeller Foundation, through the Australian National Research Council, for substantial assistance towards the expenses incurred; also to Miss O. Pink, who was engaged in social anthropology in the locality and who facilitated our enquiries. Mr. J. M. Black kindly identified many of the plants for us or confirmed our identifications, Mr. W. F. Blakely assisting us in naming the eucalypts and acacias. We have searched the journals of explorers who travelled through neighbouring regions but no information was found relating to our subject.

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The result of similar enquiries by us amongst the tribes in the vicinity of Mount Liebig, about 200 miles to the southward, has been published in these Transactions (57, 113-124, 1933).

GRAMINEAE

Themeda triandra Forst., Kangaroo grass. Ibiri; ibirri. At Mount Liebig a similar name, Tjipiri, was obtained for another grass, *Aristida arenaria*. See also *Pappophorum*.

Ichnanthus australiensis (Domin) Hughes (= *Panicum pauciflorum* Benth. var. *fastigiatum* Benth.). There were abundant dead plants (used for lighting fires) on the plains round the Granites near the camp, the seeding mostly finished. Bunnaditju; also, apparently, U-kuridja. The seeds are collected by very small ants and placed round the entrances to the nests; these grains and débris are swept up by the women into a wooden or bark dish, winnowed and ground for food, a stone (gundi, kundi) or a hand grindstone (nulli-giri) being used.

Setaria sp. Ungul; seed apparently not used.

Eriachne sp. Nga-land-ngong; seed eaten.

Pappophorum sp. Kallabidda; seed not used.

Pappophorum avenaceum Lindl. (?). Ibirri. The information noted was that this seed was also collected by ants, gathered by the women, winnowed and made into damper; but as both this and the *Ichnanthus* were in the dried state with all the grain shed, this information as regards *P. avenaceum* may be misapplied. See also *Themeda*.

Triodia spp. Monna, perhaps strictly applied only to a viscid species growing on a rise. The name birowitja was also obtained for a *Triodia*, perhaps applied to *T. pungens* R. Br., which was collected at the Granites.

PROTEACEAE

Hakea spp. Two species of corkwoods, one of them *Hakea lorea* R. Br. or *H. Cunninghamii* R. Br., with long terete leaves, and one (*H. macroptera* A. Cunn.) with broad leaves, grow on the plains round the Granites. A corkwood supplies the charcoal used for certain ceremonies associated with the Native Curren (Plectrovia latifolia) Ground-Drawing Ceremony. The twigs of the terete species, wakilbirri, are burnt to provide ash for mixing with the white man's tobacco and with the native *Nicotiana Benthamiana* before chewing the narcotics; and boomerangs are made from the wood of the tree. The same name was obtained by us for a *Eucalyptus* sp. Birrawa was also a name for a *Hakea*, probably the same species, whose ash was similarly used. Apparently the same name (pu-rua) is used at Mount Liebig for *H. lorea*. The name panguna, a corroboree totem, was also applied to both species of corkwood.

Hakea macrocarpa. Birrawa (unjeamba of Aranda peoples)—fruits termed wanarri, the word meaning thigh, which the fruit resembles.

Grevillea Wickhami Meissn. Lakkulburra.

CHENOPODIACEAE

Chenopodium rhadinostachyum F. v. M. Pruntiga, pri(c)ntiga; the seed is collected, ground and used as food.

AMARANTACEAE

Amarantus grandiflorus J. M. Black. Tjilka-la tjilka-la. Tjilka-la ngurlu refers to the minute black seeds which are made into damper, ngurlu being a general term for seeds used as human food. At Mount Liebig the same name was used for *Salsola Kali*. Tjilka = prickly. See also *Tribulus*.

Trichinium sp. (Flowers about 1½ inches long, light purple above, white below); used for personal decoration. Windilo windula. Windula suggests dindula, a common term for ornaments for the hair.

Trichinium leucoma Moq. The fluff of the flowers is used as a decoration.

NYCTAGINACEAE

Boerhavia diffusa L. Wai-ipi. Root and plant placed in the fire and root eaten. Same name used at Mount Liebig.

PORTULACACEAE

Portulaca oleracea L., the "munyeroo." Wakadi (wakati). Same name used at Mount Liebig and in the Musgrave Ranges.

MENISPERMACEAE

Tinospora smilacina Benth. or *T. Walcottii* F. v. M., a creeper with dark green hastate leaves. The stem is wound round the leg and tied to keep other plant material in position during certain corroborees.

LEGUMINOSAE

Acacia dictyophleba F. v. M. Baddutu (battutu). The seeds are pounded and used as food, ngi-i. The flowers are used as a decoration.

Acacia stipuligera F. v. M. Jilborimba; diborinda. Seeds pounded and eaten.

Acacia ancura F. v. M., Mulga. Munda. Used for making womerahs (spear-throwers).

Cassia desolata F. v. M. Warrae-ae.

Cassia glutinosa DC. (a species with large broad yellow pods). Pinambul. Not used except that the flowers serve for decorating the person.

Crotalaria, probably *C. Mitchellii* Benth. var. *tomentosa* Ewart. Tju-tju (= not used).

Indigofera viscosa L. Tjolinba.

Indigofera Georgei E. Pritzel (= *I. bovipcrda* Morrison). Bilgaru. Not used.

Psoralea pustulata F. v. M. Yagliwari.

Erythrina respertilio Benth., Beau Tree. Enundi. Used for making shields. The seeds are not eaten but are used as djindjula (ornaments). Same name (innunda) given at Mount Liebig.

ZYGOPHYLLACEAE

Tribulus macrocarpus F. v. M. Djilkala; djilka = prickles. Same name at Mount Liebig for an allied species, *T. occidentalis*. See also *Amarantus*.

MELIACEAE

Owenia reticulata F. v. M., Native Walnut. Marrangi. The very hard, rounded fruit is cracked and the kernel (which tastes like a walnut) is eaten raw, or the nut is first roasted and then cracked. The gum, munda, which resembles the gum of the golden wattle (*Acacia pycnantha*), is eaten.

MALVACEAE

Cienfuegosia australis Benth., Desert Rose. Tjubungarai (tjungarai). Flower placed in the hair as ornament. See also *Pterocaulon*.

STERCULIACEAE

Commersonia crispa Turcz. Apparently bidal bidalba. Tjutju = no good, i.e., not used.

MYRTACEAE

Melaleuca sp. Paper bark from tea-tree (*Melaleuca leucadendron* L. (?), not seen by us) is used for dabbing blood on the pattern of the ground-drawing made during the ceremony associated with the Native Currant (*Plectronia latifolia*).

Eucalyptus polycarpa F. v. M., Small-flowered Bloodwood. Orgulli. The coccid inhabiting the large galls occurring on this tree is termed yandur-i.

Eucalyptus odontocarpa F. v. M., Sturt's Creek Mallee (a green-leaved mallee with galled fruits). Marra-ra.

Eucalyptus aspera F. v. M. Brittle Bloodwood, a picturesque white-stemmed gum. Wabbanungu (wabanunga). Bark pitchis are obtained from these trees, a piece of bark of a suitable shape being loosened with a stone and then lifted off.

Eucalypt (possibly a form of *E. apodophylla* Blakely et Jacobs), resembling a small Bloodwood, probably a kind growing like a mallee. Woggilbirri; used for making spears. See also *Hakea* (Wakilbirri).

Eucalyptus sp., a mallee. Warrilya. Same name (warralya) given in Frazer Range and Hampton Plains, Western Australia (= *Eucalyptus largiflorens*, a mallee.) (Elder Expedition.)

Calythrix longiflora F. v. M. Ngangamara. The flowering branches are used for decorating the head.

CONVOLVULACEAE

Ipomaea sp., possessing a very large edible yam. Yala. This name is applied to *I. calobra* in the region of Mount Liebig.

BORRAGINACEAE

Trichodesma zeylanicum (Burm.) R. Br. var. *sericeum* Benth. Wunya-wunda. Yangir-yangiri.

VERBENACEAE

Clerodendron ovalifolium (A. Juss.) Bakhuizen (= *C. floribundum* R. Br.). Datti-pitji; dadibiji. Perhaps the root is eaten at a certain stage.

Dicrastylis ochrotricha F. v. M. Willyari. The tomentose covering of the base of the stem is used as a body decoration.

LABIATAE

Mentha? (not in flower). Tabangarai, not used. See also *Cicnifuegosa* and *Pterocaulon*. Native name probably associated with odour or perfume.

SOLANACEAE

Solanum nemophilum F. v. M. = *S. centrale* J. M. Black. Yakkadiddi (yakka-djerri). This species has a small waxy, yellowish, soft fruit when ripe with a taste between that of a gooseberry and a tomato, but slightly bitter. The fruit is readily eaten. The name goralba was also obtained, apparently for this species; and for the fruit, pilaitha (bilaitha).

Solanum phlomoides (A. Cunn.) Benth., with large purple flowers, very prickly stem and calyx, large green fruit and long flower stalk. The name kula

was obtained for an edible *Solanum*, probably this species. Ripe fruit, polka, ngaru (paru, varu); the terms polka, volka or volga are used for fruit. Readily eaten while green, provided the seeds are black. The flower is used as djindjula (ornament for ceremonies, etc.).

Nicotiana Benthamiana Domin. Muntju. This species grows luxuriantly amongst the rocks on granite knolls. The leaves are first moistened by being chewed for a short time, and then the mass is rolled in ashes obtained by burning twigs of *Hakea* (probably also of *Acacia*) and allowing the ashes to fall into some flat receptacle. The quid is chewed for its narcotic qualities and eventually passed to other natives. The roll is carried behind the ear when not in use. The leaves are eaten by the young and old men and the old women, but not by young girls. We observed one old woman fill her mouth with the fresh leaves and swallow the bolus. The native name given to us by children was tukkamulla. We also obtained the name tangungnu for the plant.

RUBIACEAE

Electronia latifolia (F. v. M.) Benth. et Hook., Native Currant. This plant which was used as the motif in a ceremonial ground-drawing at Miss Pink's camp, does not grow in the vicinity of the Granites but occurs some miles away. The very dark-coloured juice of the fruit is squeezed out and drunk. *Hakca* sp. (corkwood) is used to supply the charcoal for this ceremony and paper-bark from a tea-tree (perhaps *Melaleuca leucadendron* L.) for dabbing blood on the pattern.

CAMPANULACEAE

Wahlenbergia Sieberi DC. Korivaru.

GOODENIACEAE

Velleia connata F. v. M. Kulbirl kulbirlka; not used.

COMPOSITAE

Pterocaulon glandulosum (F. v. M.) Benth. et Hook. Tjung-arai tjungarai. The aromatic leaves are used for a cold in the head by being inserted into the nose through the perforation of the septum. The name tjubajari was also obtained for *Pterocaulon*, either this species or *P. sphacelatum* (Labill.) Benth. et Hook. Perhaps the native name has reference to the perfume. See also *Cicnufugosia*.

GASTROMYCETE FUNGUS

Podaxon pistillaris (L.) Fr. No-wun; the purplish spore powder is used for decorating, e.g., by children imitating the slashing of legs.

The following general terms are employed:—Flower or seed of any kind, used as ornament, etc.—djindjula. Plant and leaf; borrla. Fruit; polka, volka, volga. Ngulu, or better ngurlu, is used in addition to the name of a grass or other plant to indicate that the seed is referred to (and used) as a seed food. Food; mung-ari.

NOTES ON THE ABORIGINES OF THE SOUTH-EAST OF SOUTH AUSTRALIA PART II

By T.D. CAMPBELL.

Summary

Part I of this study has been published in these Transactions⁽¹⁾ and its purpose was to place on record some observations collected by the writer and to collate the sources of information which have already been published in various volumes and scientific communications.

NOTES ON THE ABORIGINES OF THE SOUTH-EAST OF SOUTH AUSTRALIA

PART II

By T. D. CAMPBELL

[Read 13 April 1939]

Part I of this study has been published in these Transactions,⁽¹⁾ and its purpose was to place on record some observations collected by the writer and to collate the sources of information which have already been published in various volumes and scientific communications.

The present notes are an endeavour to bring together scattered items of information derived from early newspaper reports (mainly "The Border Watch," Mount Gambier), Government Gazettes, Parliamentary Papers, and official correspondence; the last-mentioned being in original manuscript form in the Archives Department of the Public Library. Some concluding paragraphs will deal with the decline of the aboriginal population.

The bulk of the material contained in these sources of information consists of statements and reports by laymen and Government officials, who were concerned with the contact of a newly settling group with the indigenous inhabitants of the area concerned. Such information is interesting and instructive, but rather outside the scope of the present study, which is mainly a search for ethnographic detail. A careful search has been made in order to cull any pieces of information which will add to our knowledge of what these particular natives were like and how they lived in their natural state. In addition, the writer has endeavoured to draw from a collection of rather vague and unpretentious statistics some sort of estimation of the original population and rate of its decline. The present extracts, together with those already published, will incidentally illustrate the inevitable clash which took place between white settlers and the aboriginal landowners.

THE NATIVES AND THEIR HABITS

As mentioned above, detailed information regarding the natives and their habits is scarce. But in the sources of the present enquiry, one official report in particular stands out as quite a gallant little effort on the part of its writer to enlighten his superiors concerning the natives of his district. The report seems worth quoting almost in full. It was written from the Aborigines' Department at Guichen Bay by W. Warren, native officer, on 2 January, 1860; the following paragraphs are contained therein:

⁽¹⁾ Trans. Roy. Soc. S. Aust., 58, 22-32, 1934

“I BOUNDARIES DEFINED

“I will first define, as requested, what I consider to be the boundaries of this district over which I am required to supervise, commencing from Robe Town to Woakwine (the situation of Mr. John Scott), from there to Lock’s Eating House, Reedy Creek, thence pursuing a northerly direction to Blackford, Mr. Gifford’s station, from thence to Matherson’s Station (near the coast), thus including the country known as ‘Tilly’s Flat,’ ‘Baker’s Range,’ ‘Maria Creek,’ and ‘Mount Benson Range.’

“II ABORIGINES OF THE DISTRICT OF ROBE

“If I may be allowed unreservedly to express my opinion upon the Aborigines of this district, after some little experience in other parts of the Colony prior to a five years’ residence in this particular locality, I must remark that I consider them far inferior, both mentally and physically, particularly the latter, to any Australian natives I have ever been acquainted with—bearing no comparison in the above-named qualities with the tribes of ‘Mount Gambier,’ ‘Salt Creek,’ ‘Murray River,’ ‘Lake Alexandrina’ its tributaries, and ‘Encounter Bay’; perhaps I ought to premise that if as a body I consider them deficient in intellect compared with the above-mentioned tribes, I believe them in other respects to be vastly superior, and am justified in making this assertion as reference to police records will prove. For some years past these natives appear to have possessed an intuitive sense between right and wrong, carefully avoiding the latter even when seductive temptation has accidentally been thrown in their path. Of this I could adduce several remarkably pleasing instances that have from time to time come under my own observation; and conscious that the slightest violation of the law is sure sooner or later to be visited upon them, the terrors of which they have naturally the most wholesome dread, hence the paucity of police cases from this district for capital offences. Indeed, the cases in which the Aboriginal population of this quarter have been brought under notice have related more particularly to disturbances among themselves, such as feuds and jealousy, causing petty quarrels ending in more words than blows, and should it so happen they resort to the latter, the spear is but very seldom used. The population of the district of Robe, as above defined, I consider on approximation to be 100 souls, men, women and children.

“III MORTALITY OF THE ABORIGINES

“I would beg to enter further and more minutely into this subject, which has apparently without any assignable cause, particularly during the last few years, exceeded belief. From information I gather, it would appear this district is not alone in this respect and that native tribes all over the colonies are equally affected. I am informed by a gentleman who has been a resident in this part for several years past and competent to form an unprejudiced opinion, who estimates that upon a rough calculation at least two-thirds (if not more) of the original number during the last twelve years have disappeared, and that the majority

of these deaths he believes to have proceeded from natural rather than violent causes. I noticed during the year 1856 an unusual mortality among the able-bodied young men within that year at intervals of time, and in various localities I remarked no less than eight deaths, and, with one exception, I believe all apparently free from syphilitic complaint. A few of them who died in or about Robe Town had the advantage of medical treatment, the remainder dying at the stations of distant settlers I believe had every necessity and comfort supplied them as far as practicable, with that kindness and attention for which that class of persons have long since become so remarkable. During the last quarter there has been but one death, that of a middle-aged man who has been gradually sinking for some time past.

“IV MIGRATION

“The natives of this district interchange occasional visits with adjacent tribes, but at no particular stated periods, an arrangement mutually agreed upon some time previously when they muster in full force to celebrate the ‘Cooyonny,’ somewhat similar to the well-known ‘Corroboree’ of the Aborigines in the more settled districts. For the last four years Robe Town has been regularly visited during the winter by the natives of the ‘Coorong,’ of ‘Salt Creek’ and ‘Mount Gambier,’ all of the adults of whom are intelligent, industrious workmen, making their own bargains and completing extensive undertakings such as fencing, colt-breaking, etc., but these visits never extend beyond two or three months and are regarded as tokens of friendship by our natives, no disturbances ever having taken place between them rendering interference of the police necessary.

“V SERVICES OF THE ABORIGINES

“As already intimated, the natives of this district have not the activity of mind or body possessed by their neighbours, and this is strikingly exemplified by the fact that, if they can possibly exist without, they will not work. During the shearing or lambing seasons the settlers obtain their services, but from their well-known restless habits no dependence can be placed in them; the females are generally employed and are found to be expert washerwomen; the young men sometimes continue for twelve months in one employ as bullock drivers, stock-keepers, or colt-breakers, work more congenial to their disposition than any other; and I must here remark that as bullock drivers they are patient and persevering, as stock-keepers or drovers acute and mindful, and as they are generally speaking skilful horsemen, they use mild and kind treatment in breaking in colts.

“VI CUSTOMS AND HABITS

“The natives of this district have somewhat similar superstitious observances as those of other parts of the Colony. They believe in good and evil spirits, they bury their dead, whom they mourn with much affection and never after death mention the name of the deceased. In their long intercourse and continual contact with the lower classes of Europeans they have imbibed their vicious propensities, likewise an inordinate love for spirits and tobacco; in the too frequent indulgence

of the former I believe may be traced the secret but real cause of their present gradual and certain ultimate extermination, but it gives me great pleasure in here stating that there has been a check continually kept alive to prevent the Aborigines of this district from getting excess of that slow but deadly poisonous beverage, and the result, I am happy to state, has proved satisfactory.

“W. WARREN.”

The following note concerning the region inland from Robe is taken from a letter written on 1 November, 1853, by Thomas Chirnside to La Trobe, sometime Governor of Victoria: “I formed a station on the Adelaide territory, 40 miles from Guichen Bay, about the end of 1845. I found the habits, etc., of the natives there the same as in Port Phillip, but was surprised to find they could not swim; and believe, until lately, they never had the opportunity, as I am informed ten years ago they could only get water by digging for it.”

The following show either the native's dislike of exertion, or, possibly more likely, his disinclination to move from his own particular territory unless he has some special desire or motive for doing so.

A report of a visit to the South-East made by the Acting-Protector, dated 20 March, 1867, contains the following paragraph:

“8th inst. I drove to Mount Burr and visited the native encampment. There were 17 natives here, two of whom were sick and under the medical care of Dr. Peel. I offered to give them an order on Mr. Egan for rations for the sick persons, if the able-bodied would undertake the little journey of 20 miles—my offer was refused, but would have been accepted if I had hired a horse and cart, which I refused to do. Game is very abundant at this place, and with a small amount of exertion a large quantity can be obtained at any time. Mount Burr is a favourite resort of the natives and would be a better place for a depot than Tarpeena.”

The next incident was mentioned by the Protector in a report of 31 July, 1848, following a visit he made to the South-East.

“I endeavoured to assemble the various tribes (sic) about Mount Muirhead, Biscuit Flat and Rivoli Bay, at Guichen Bay to distribute flour to them and address them through an interpreter, but I did not succeed. A few days before, three men and one woman who had been liberated from Gaol, in Adelaide, had rejoined their tribes, and a series of festivities had commenced which they would not suspend for the sake of a present of flour.”

The following notes deal with natives of the Tarpeena district which is situated some miles due north of Mount Gambier. It was a settlement from the early days of civilized occupancy of South Australia. Official records show that it was for many years one of the main ration distributing depots for the natives. There is little information which will help us to understand the relationship between the Tarpeena natives and those which we believe definitely belonged to the Buandik tribe. However, as this locality falls within the area defined as the South-East, a few points concerning it might suitably be included here.

A previous note mentioned the reluctance of Mount Burr natives to journey to Tarpeena for rations. Whether this was due solely to laziness or involved the matter of group boundaries it is difficult to say. The following note seems to suggest at least some friendliness between the various groups. But it must also be observed that the occurrence is of a date when serious disorganisation of tribal customs and boundaries had already taken place through white settlement.

Ranger Egan reported on 13 May (Govt. Gaz., 1867, 664): "All the aborigines located at the depot at Tarpeena left for MacDonnell Bay; some of them had never seen the Bay and were very desirous to visit it. They subsequently returned to the Mount, where they met many friends, some from the Glenelg, and they held a corroboree."

A departmental report of June, 1866, contains the following note concerning the Tarpeena natives: "They had one 'growl' during the month about a lubra, and were going to fight. Some painted their faces white, and thirty men and women arranged themselves in battle array in a paddock opposite my house, with their spears, waddies, etc. Fortunately, I happened to be at home and so prevented the fight, and they soon became very good friends."

The following remarks, taken from a letter written by E. P. S. Sturt on 20 October, 1853, also serve to record the contact of early settlers with the original inhabitants:

"My residence since 1844 has been at Mount Gambier. . . . The natives were very inimical when we first arrived, and, to add to my difficulties, all our men with the exception of one deserted us. . . . Our neighbour, Mr. Leake, suffered many losses from the natives, some thousands I believe, but we escaped any attack, which I attribute to the astonishment they evinced at seeing the effect of a good rifle aimed by a correct eye. . . . I have always thought this gained us their respect. They gave me the name of a chief who had fallen in battle, and affirmed that I had again come among them as a white fellow. We gained their respect, but it was through fear, and, subsequently, their confidence through kindness. Many of them have since become useful shepherds, and have been of the utmost service to me, but it is difficult to have fat sheep where natives shepherded them, for they are too indolent even for that service."

It is an interesting point to note the manner in which these natives evinced their respect for Sturt by declaring him to be a re-incarnation of one of their no doubt revered "chiefs." Possibly a subtle way of avoiding an admission of the superiority of the newcomer.

The Protector's Report (dated 31 January, 1849) for the quarter ending 31 December, 1848, states: "At Guichen Bay Captain Butler, the Resident, reports that the natives who formerly were too timid to approach the settlement, are now beginning to possess more confidence, and are rendering service to the Europeans—and the same may be reported of Mount Gambier and Mount Remarkable districts."

MISCELLANEOUS NOTES

In the "South Australian Figaro" of 8 January, 1878, appears an account of a native legend which describes how MacDonnell Bay was formed. The paragraph was contributed by "a lady correspondent" and is, word for word, the same as a legend given in Mrs. Smith's book on the Buandik, published in 1880. It seems quite probable that Mrs. Smith was the newspaper contributor.

From the Protector of Aborigines' Report, 16 April, 1847: "A European named Donnelly was tried for the wilful murder of a native near Rivoli Bay. He was found guilty and sentenced to be executed on 29 March. The sentence was carried into effect. This is the first instance of a European having been found guilty for a capital offence against a native of this province."

E. P. S. Sturt, in a letter of 20 October, 1853, described the occurrence of caves in the Mount Gambier district; he related the following interesting incident: "I have never discovered any petrification in these caverns, but I thought once to have discovered something that would have handed my name to posterity. In one of these niches I observed the figure of a man, bent as in an attitude of thought, his elbows resting on his knees. I approached and felt this object, when I found it to be the body of a man I supposed petrified. Anxiously I examined it, and took an arm and hand, which were loose, to the open air for closer inspection. I then found that it had more the appearance of a mummy, the skin having become hard and dry and containing nothing but dust. It, however, merited closer inspection, but I had some miles to ride and determined to defer such examination to another time. Since then I have never been near the spot." This is probably an example of a desiccated body; very few of such specimens have been recorded or collected.

The Protector's Report for 21 March, 1848, relates to the appointment of D. S. Stewart (son of Mrs. J. Smith) as official interpreter of native language for the South-Eastern district, at a salary of £33 6s. 8d. per annum.

ABORIGINAL POPULATION AND ITS DECLINE

The following notes can hardly be described as vital statistics, because the sparseness and irregularity of early official reports and the data contained therein make it difficult to arrive at an accurate assessment of the numbers of aborigines in the early years of the South-East. The only sources for population estimates are the statements of various observers who passed through the district and official records which purport to give the numbers of natives attending ration depots. In the latter half of last century some State Census Reports include figures on the aboriginal population.

Regarding the estimates of unofficial observers traversing the country, the danger of too much reliance on them is shown by statements concerning the apparent absence of natives along the route; or the avoidance of white man by deserting their camps on his approach, and so on.

The official figures also have to be considered in the light that consecutive reports show marked fluctuation in numbers for the same district. This was no doubt due to irregular and seasonal requirements by settlers of native labour, weather conditions, the state of natural food supplies, all affecting the aborigines' attendance on the distributing depots for their sustenance and supplies. Thus official figures can only be taken as an approximation.

DEPOPULATION

From the earliest accounts of the South-East it may be safely assumed that up to 1840 the Buandik aborigines were, in the main, still living their natural life; and that, until then, their numbers were probably unaffected by whatever civilized contact had occurred. Official records show that by the late forties many aborigines were employed as shepherds and shearers; and also the Government system of providing food rations and blankets had become established. Government assistance was, of course, an attempted recompense for the usurpation of native hunting grounds by the considerable land settlement already effected. Tribal boundaries and customs were seriously disintegrated. Previously recorded reminiscences by Wallis (erroneously spelt "Wallace") showed that by the late fifties the Buandik had obviously diminished in numbers and segregated into a few localized communities. Then reports in early numbers of the Mount Gambier "Border Watch" show that by the early sixties the natives of that district had long since become completely detribalized and the remnants of local groups formed a struggling camp of "hangers on" in the township, creating disturbances whenever they managed to obtain strong drink. The sympathy of Mrs. James Smith and the purpose of her "Aborigines' Home" constituted a noble effort on behalf of these unfortunate derelicts who had been dispossessed of their native territory.

When once the tribal life of the aborigines had been broken up, the story of their remaining days—both in official and newspaper reports—is a sad chronicle of odd numbers of better known identities passing out in disease and distress; and nothing is told of the many who went to their native soil unknown and unrecorded.

The following remarks on population figures are not put down as any sort of accurate statistical survey. The data have been derived from many and varied sources in the form of early reports, documents, letters, Government Gazettes, and Parliamentary Papers; the details are of an exceedingly fragmentary nature, vaguely scheduled, and not available in any regular yearly sequence. Therefore, the attempt to arrive at any estimate of early aboriginal population and its decline cannot produce more than the merest approximation. Nevertheless, it is felt that a few points of interest are made available.

As mentioned above, 1840 may be taken as a time when the aboriginal population of the South-East was as yet practically unaffected by settlement in South Australia. Anything in the nature of a census at this early period was

unknown, and estimates of population at this early date must be looked on as little more than guess work.

An official report for February, 1848, gives a total of 400 natives for the areas associated with Maria Creek, Guichen Bay and Rivoli Bay down to Mount Gambier. Several other estimates have suggested 2,000 as being a likely figure. If any safe inference can be drawn from some figures given below, it is possible that the larger estimate is nearer the mark, especially as the South-East has always been a well-watered region and described as abounding in native food supplies. It surely could have supported a much larger population than the 400 estimate, which probably took into consideration only those aborigines associated with the coastal route from Adelaide to Mount Gambier.

The following figures appearing in a number of census reports throw a significant light on our requirements.

Population	....	....	....	1861	1866	1871	1876
				324	151	82	55

From these figures it is seen that, at a rough approximation, the population declined 50 per cent. over each five-year period.

From other sources of information, the census population stated for 1861 can be looked on as probably somewhere near the actual numbers. The previously recorded observations of one of the writer's old informants (Wallis) showed that by the late fifties the Buandik were reduced to about five localized groups of about 60 natives in each. Egan, a local police officer, reported in 1866 approximately 200 natives for his district, which was the Mount Burr-Tarpeena region; it probably contained at least half of the total population, seeing that districts like Mount Gambier and Robe were by that year markedly depleted in aboriginal numbers.

So that if we concede the above suggested rate of depletion as likely, but also allowing that the rate was probably accelerated with closer white settlement, it will be seen that a population for the early forties of 2,000-2,500 individuals would be a reasonable estimate.

From other figures this rapid rate of depopulation is further borne out. A rough computation of fragmentary data on the Mount Burr region, for example, gives the following:

Mid Forties	Mid Fifties	1860	Late Sixties
150	60	20	15

Most detailed data available concern Robe during the earlier periods under consideration; from them it can be estimated that at about 1848-1850 there must have been 150-200 aborigines in the district; Warren's official report states 100 for 1860; for 1862, it is officially recorded that "20-25 are usually in the neighbourhood." Then, in 1875, the average number reporting at the ration depot was 7.

For the Mount Gambier district, various contemporary local observers mention the natives as being in "great numbers" at the middle of the century; by 1874 the population is recorded as 19.

Quoting again from Warren's Report (1860): "I am informed by a gentleman who has been a resident in this part for several years past and competent to form an unprejudiced opinion who estimates that upon a rough calculation at least two-thirds (if not more) of the original number during the last twelve years have disappeared."

As the century drew to its close, we see the same rapid disappearance holding sway as was shown above by the series of census returns. In 1876 the population was about 55; twenty years later, by 1895, it is well known that probably only two full-blooded aborigines of the South-East remained; and before 1900 the Buandik were completely gone.

Attempting a general interpretation of the above evidence, and other available data, it seems fairly evident that in the early forties the aboriginal population was at its natural level, possibly about 2,000 in number; in 1895 the death of the last surviving full-bloods of the South-East was recorded. This territory was a well-watered, fertile region, and is stated to have carried an abundance of game. Yet so surely does the encroachment of civilized settlement bring about decline of the aborigines that, as the above figures roughly indicate, every five-year period saw a reduction of about fifty per cent. of the indigenous population. Half a century, and all were gone. This unfortunate dying out, which seems to be almost the inevitable fate of primitive landowners when their territory is usurped by people of a higher culture, may not be quite so rapid a process as that effected by the implements of modern warfare, but the end result seems far more fatal to the primitive group concerned.

The writer wishes to express his indebtedness to Mr. G. H. Pitt, B.A., of the Archives Department, for his expert assistance in the search through obscure sources of information; and to the Board of Governors for the facilities for this type of research. Also to Mr. Roland Campbell, of Millicent, for helpful suggestions.

SUMMARY

This paper is a continuation of a previously published part of a study which has endeavoured to collect various scattered pieces of information on the life and habits of the aborigines of the South-East of South Australia.

The present notes consist of brief descriptions culled from early Parliamentary Reports, newspapers, and official letters.

Some remarks are included which attempt to derive from sparse census and population data an idea of the original aboriginal numbers and the rate of population decrease with the advent of civilized settlement.

CLIMATIC FACTORS IN RELATION TO THE AGRICULTURAL REGIONS OF SOUTHERN AUSTRALIA

By H. C. TRUMBLE D.Sc., M.Agr.Sc. (Waite Agricultural Research Institute)

Summary

The length of the growing season for agricultural plants in South Australia has been shown, in a previous publication (2), to depend on the annual period of moisture availability, which varies considerably over the State. In this connection, use was made of the "period of influential rainfall," which was defined as the time interval over which the surface soil (0-4") tended to be maintained above the wilting point for herbage plants. This was found to be equivalent to the period over which rainfall exceeded approximately one-third of the monthly evaporation from a free water surface. In the absence of sufficient evaporimeter records, values for the mean monthly saturation deficiency were found satisfactory for the determination of evaporation.

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[Read 11 May 1939]

INTRODUCTION

The length of the growing season for agricultural plants in South Australia has been shown, in a previous publication (2), to depend on the annual period of moisture availability, which varies considerably over the State. In this connection, use was made of the "period of influential rainfall," which was defined as the time interval over which the surface soil (0-4") tended to be maintained above the wilting point for herbage plants. This was found to be equivalent to the period over which rainfall exceeded approximately one-third of the monthly evaporation from a free water surface. In the absence of sufficient evaporimeter records, values for the mean monthly saturation deficiency were found satisfactory for the determination of evaporation.

The mean period of influential rainfall and the mean quantity of influential rainfall as single value climatic measures were correlated with climax vegetation, soil type and the type of agricultural or pastoral activity practised. From the combined evidence thus obtained, a series of edapho-climatic zones was finally derived for South Australia.

More recently, Moreau (1) has reviewed the various climatic classifications that have been proposed, with particular reference to their possible use in mountainous country within a few degrees of the Equator. None of the formulae available can be adopted in their entirety for East African conditions, and the present author's method, though accepted in principle by Moreau, cannot be employed under his conditions, owing to the absence of records of evaporation. Moreau affirms that three distinct criteria are necessary for bio-climatological classification, namely, (*a*) temperature, (*b*) duration of the effective rainfall period, and (*c*) the effective rainfall.

In the author's analysis of South Australian conditions, the two latter criteria were employed; differences in temperature were found to be so slight as to be of comparatively restricted local importance.

TESTS OF CRITERIA EMPLOYED

The present paper is based on the method of climatic analysis described previously and extends the examination commenced therein to the agricultural areas of southern Australia generally. Over this more extensive region, involving material differences in both latitude and altitude, the temperature factor becomes important.

Before commencing an examination of the remaining southern States, tests were made of the results obtained in South Australia. Further field experience, as it became available, was considered in the light of the edapho-climatic zones previously constructed. There appears so far to be no indication of anomalies or any reason for modification of the generalized types formerly provided, although as time progresses, greater detail is certain to be required.

The establishment of an evaporimeter at Pallamana, near Murray Bridge, in May, 1937, has given an opportunity for checking the calculated evaporation

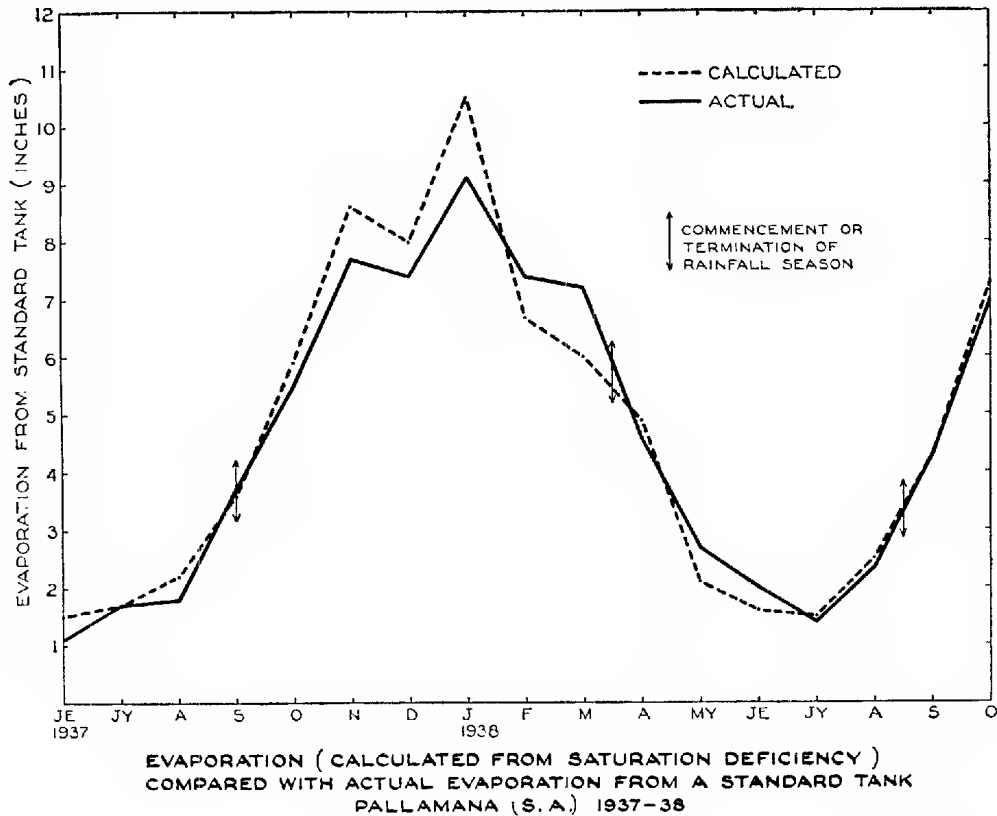


Fig. 1

values employed, based on saturation deficiency for 25 stations combined with interpolation, by reference to actual evaporimeter records. Fig. 1 provides a comparison of the calculated and observed values at this centre for the period June, 1937, to October, 1938. The calculated values were determined from standard monthly means, applying a seasonal correction based on the Waite Institute values for the same period, related to the Waite Institute monthly means. The calculated and observed values give a highly satisfactory agreement.

Further tests of soil evaporation carried out by Woodroffe (3) on different soil types have shown rather more fluctuation in the type of evaporation curve, according to the rate of free water evaporation and the moisture content of the soil,

than was found in the case of the Waite Institute soil, on which the original determinations of soil evaporation were made; but these have not indicated any alteration in the factor $0.3E$, which appears to be the most suitable factor for use in conjunction with rainfall, under South Australian conditions.

Further work by Woodroffe (*loc. cit.*) has confirmed the fact that evaporation from a saturated soil surface is much the same as that from free water; and higher values that have been quoted by other workers would appear to have been obtained with irregular soil surfaces, or where the soil loss has included the

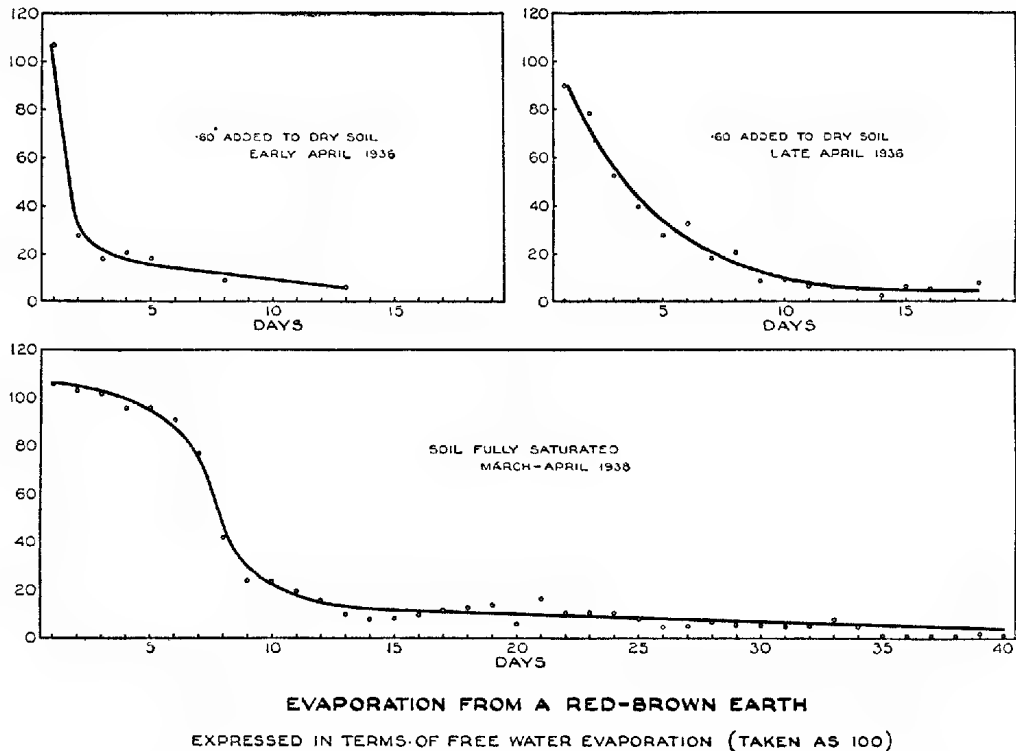


Fig. 2

transpiration of growing plants. In the work mentioned above, a rate comparable with that from free water was sustained from full saturation until approximately 50 per cent. of the saturation capacity had been reached, after which the rate of evaporation fell rapidly.

POSSIBLE VARIATION IN THE EVAPORATION FACTOR

In fig. 2 a comparison is made of the rate of evaporation from Waite Institute loam following moderate falls of rain, but under differing rates of free water evaporation, taking the latter in all cases as 100. In the ideal case, where the rate of free water surface evaporation remained constant, a straight line from 100 to 0 would give a value of 0.5 from the initial wetting to the wilting point value. As the curve is invariably bent downwards to a much greater extent than upwards, the factor to be employed for soil evaporation tends to be lower than

0.5. It will be seen from fig. 2 that as the rate of evaporation rises, the curve tends to become L-shaped, giving a lower factor for soil evaporation; while under conditions of decreased free water evaporation, the curve more nearly approaches a straight line, indicating a factor closer to 0.5. It would be reasonable to suppose, therefore, that if the factor of 0.3 is suitable for South Australian conditions, as appears to be the case, a factor of the order of .20 or .25 might prove more suitable for Queensland or northern New South Wales, whereas under the conditions of low evaporation which occur in Tasmania, or south-eastern Victoria, a factor approaching 0.5 might prove to be more satisfactory.

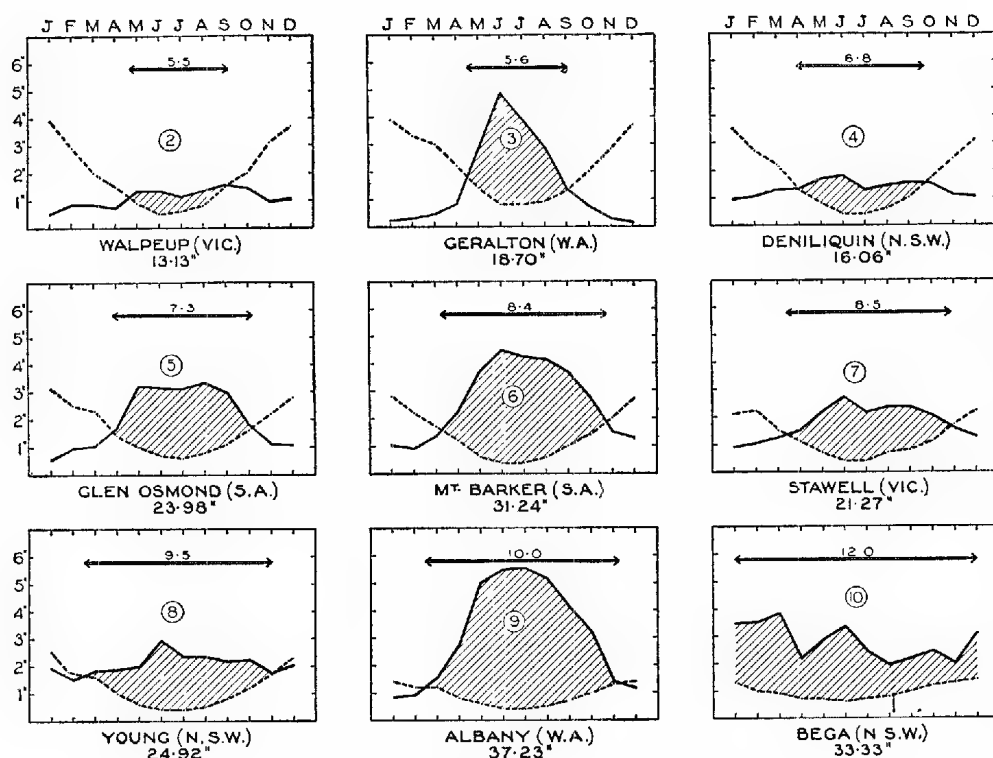


Fig. 3

Showing the mean length of the rainfall season for selected centres in southern Australia, as determined from the relationship between mean monthly rainfall (continuous line) and one-third the mean monthly evaporation (dotted line).

There can be no justification for the use of these alternative factors until investigations of soil evaporation have been carried out in the particular localities concerned, and in the present work the factor 0.3 has been retained for southern Australia generally. The results obtained may be subject to some revision in the eastern States, following local investigations of soil evaporation, particularly in the northern and extreme southern portions. Fig. 3 shows the mean values for a number of representative centres in various southern States, using the factor 0.3E.

TEMPERATURE FACTORS

The mean monthly air temperature has been taken as the most convenient single measure of temperature. In general the three winter months, June, July and August, are critical in southern Australia, so far as the limitation of growth by low temperatures is concerned; and the mean air temperature for each of these three months has been taken as a criterion of winter-growing conditions. Reference to field experience in various parts of South Australia, Victoria and Tasmania has indicated that the following values would serve as lower limits to various categories, representing different types of growth: (1) absolute growth, 45°F. ; (2) moderate growth, 50°F. ; (3) active growth, 55°F.

A comparison of four selected centres, differing widely in their temperatures and moisture relationships is given in fig. 4, in which the amount of monthly

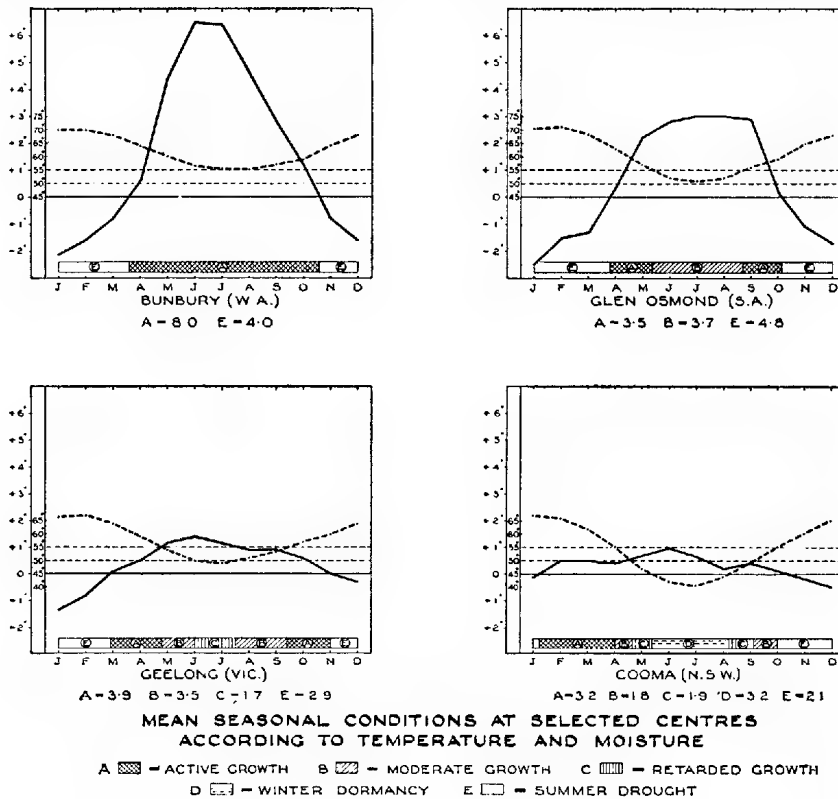


Fig. 4

rainfall is expressed as the amount above or below one-third of the monthly evaporation, which is taken as 0. Excess or deficiency of available moisture is then taken, with temperature, to delimit varying periods throughout the year.

RELATION BETWEEN RAINFALL AND LENGTH OF SEASON

In fig. 5 the mean length of the rainfall season has been plotted in relation to the mean annual rainfall for a comprehensive range of stations in southern

Australia, and according to their position on the graph, the various centres have been separated into 10 classes, depending on the criteria listed in the legend.

It is of interest to note the occurrence of various well-known centres in the different sections of the graph.

Class	Type	Rainfall Season (Months)	Annual Rainfall (Inches)	Centres
1	Pastoral	<5.0	6-14	Lawlers (W.A.), Koonamore (S.A.) Wilcannia (N.S.W.)
2	Cereal	5.0-6.0	12-16	Salmon Gums (W.A.), Merredin (W.A.), Minnipa (S.A.), Pallamana (S.A.), Walpeup (Vict.), Hillston (N.S.W.), Griffith (N.S.W.)
3	"	"	16-20	Chapman State Farm (W.A.)
4	"	6.0-7.5	16-20	Roseworthy (S.A.), Nhill (Vict.), Longerenong (Vict.)
5	"	"	20-35	Waite Institute (S.A.)
6	Grassland	7.5-9.0	16-30	Kybybolite (S.A.), Rutherglen (Vict.), Wagga (N.S.W.)
7	"	"	20-50	Bunbury (W.A.), Mount Barker (S.A.), Meadows (S.A.)
8	"	9.0-10.5	18-30	Hamilton (Vict.), Werribee (Vict.), Canberra (F.C.T.), Young (N.S.W.), Bathurst (N.S.W.)
9	"	9.0-10.5	30-50	Albany (W.A.), Mount Gambier (S.A.)
10	"	>10.5	18-50	Maffra (Vict.), Orbost (Vict.), Richmond (N.S.W.), Sydney (N.S.W.), Tasmanian centres

The above classification does not take into consideration temperature or soil type, both of which may be expected to separate further the centres within each of the above classes.

CLIMATIC ZONATION OF AGRICULTURAL AREAS IN SOUTHERN AUSTRALIA

The map shown as fig. 6 summarizes the results of applying two of the criteria previously described, namely the period of influential rainfall and the mean monthly temperature for the three winter months, to southern Australia. A tentative outer limit to successful wheat culture, based on the 5.0 months' isochrone for influential rainfall, is shown on the map, and this could be regarded as an extension of the well-known "Goyder's Line" of South Australia to southern Australia generally. The probable outer limit to the culture of Mount Barker subterranean clover is indicated by the 7.5 months' isochrone, while the limit to the development of European and New Zealand pasture mixtures and methods of husbandry is indicated by the 9.0 months' isochrone. The map further provides an interesting comparison of the essential climatic features of the wheat belt of Western Australia and South Australia on the one hand, with those of the wheat belt of Victoria and New South Wales on the other. In the former case the season tends to be rather shorter, and is materially warmer than in the eastern

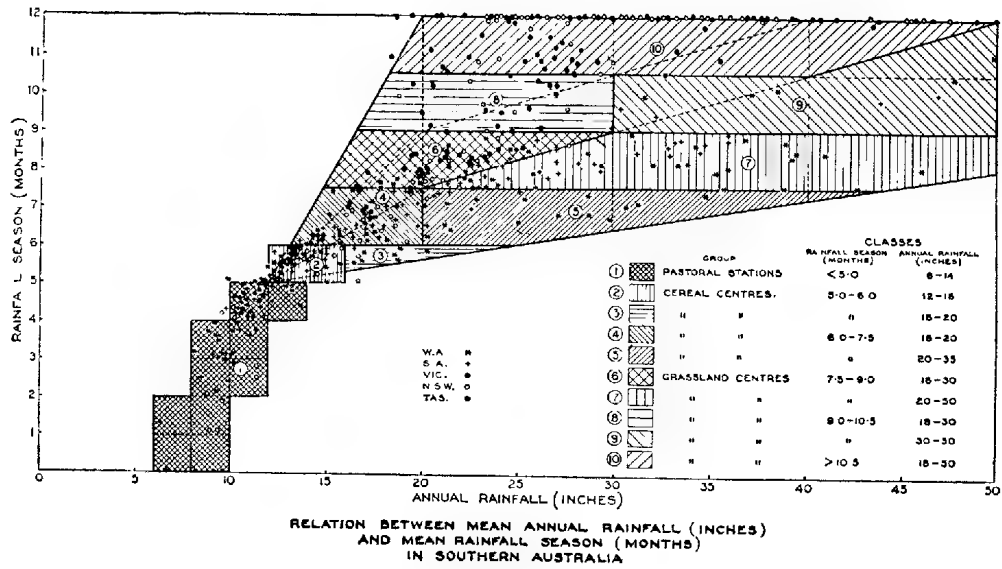


Fig. 5

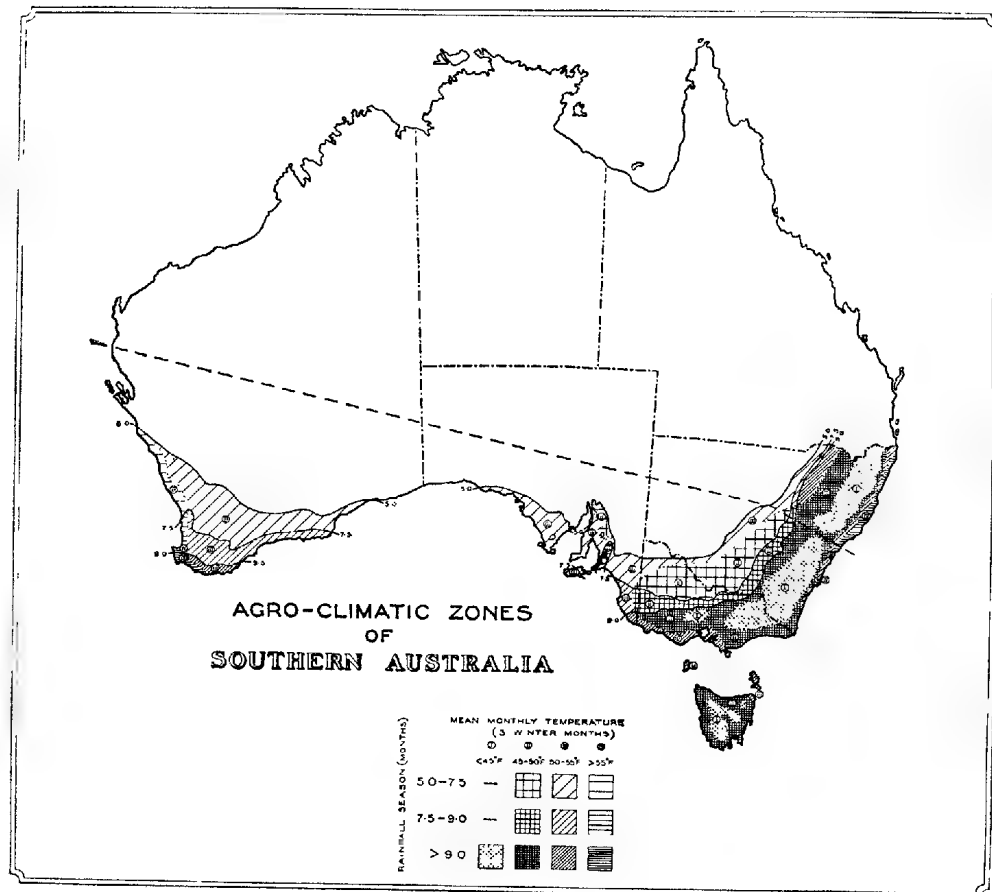


Fig. 6

States, where a longer but cooler growing season prevails. In view of these differences, it is not surprising that wheat varieties of outstanding performance in South Australia and Western Australia are not generally so well adapted to Victoria or New South Wales, and *vice versa*.

The work of zonation, based on the criteria described above, has proved straight-forward up to Griffith Taylor's line indicating the approximate region of transition from the winter rainfall to the summer rainfall type. Above this line the present work has been carried to the northern border of New South Wales, but in northern New South Wales and southern Queensland the criteria so far employed become of doubtful value, owing to a less definite cross-over between rainfall and evaporation together with an increased variability between seasons. The variability factor is of particular importance to the agricultural and pastoral industries of Australia and requires detailed investigation. The validity of the methods so far employed pre-supposes relative stability of the mean values derived in the areas covered. This is considered to be sufficient, within the agricultural areas of southern Australia, to provide a legitimate basis for the construction of permanent climatic zones; and a further step is the determination of variability as applied to the length of the season, the influential rainfall and temperature at representative centres within each of these zones. In the case of the northern agricultural areas of Australia, however, a consideration of individual seasons and their variability may have to be taken into account in any system of classification or zonation based on climatic factors.

SUMMARY

The methods previously employed by the author as a basis for the climatic classification of the agricultural areas of South Australia are reviewed in the light of further experimental evidence and field experience, and the examination of available climatic data is extended to embrace the agricultural areas of southern Australia generally.

A map showing the agro-climatic zones of southern Australia, based on the mean length of the rainfall season and mean winter temperatures is included.

The use of mean values appears to be satisfactory for climatic zonation in southern Australia, but the variability factor requires yet to be investigated for each zone. In the areas of northern Australia receiving summer rainfall, it is probable that the individual seasons may require greater consideration in the initial classification into generalized climatic zones.

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SOME NEW AUSTRALIAN LEAF-HOPPERS (HOMOPTERA, JASSOIDEA)

By J. W. EVANS MA., D.Sc., F.R.E.S,

Summary

ULOPIDAE

Uloprora gen. nov.

The head is narrowly produced, the apex tilted dorsally; the produced portion, which consists solely of the vertex, is laterally flattened and keeled both dorsally and ventrally. The ante-clypeus is sunk below the level of the lora and the fronto-clypeus, the latter is somewhat depressed posteriorly between the antennal pits. Coronal and epicranial sutures are distinct, but there is no trace of frontal sutures, and the ocelli which are on the crown of the head lie well in front of the eyes. The tegmina narrow apically and the veins raised in relief. Wings are absent. The hind tibiae are short with small feebly-developed spines.

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[Read 11 May 1939]

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Uloprora risdonensis sp. nov. (Genotype)

(Figs. 1, 2)

Length, 5 mm. *Head* punctate, covered with sparse white hairs; ventral surface chestnut-brown posteriorly, black anteriorly but for the fronto-clypeus which is grey between the antennal pits. Vertex greyish-brown with a pair of longitudinal dark brown stripes on each side. *Pronotum* punctate, chestnut-brown. *Tegmen* hyaline, veins light and dark brown. *Thorax* and *abdomen*, ventral surface and *legs*, light and dark brown.

Type ♀, from Risdon, Tasmania (coll. V. V. Hickman), in the collection of the Australian Museum, Sydney.

Austrolopa victoriensis sp. nov.

(Fig. 3)

Length, 4 mm. *Head*, ventral surface pale brownish-yellow, but for the eyes and an area below each antenna, which are black. Crown pale yellowish-brown. *Pronotum* declivous, grey mottled with black. *Scutellum* grey, anterior angles black. *Tegmen* transparent, veins brown; claval area coriaceous. *Thorax* and *abdomen*, ventral surface pale yellowish-brown.

Type ♀, from Warburton, Victoria (coll. F. E. Wilson), in the collection of Mr. F. E. Wilson, Melbourne.

The shape of the heads of the two species described above is sufficient to distinguish them from the two species of the Ulopidae previously described from Australia. It would seem that the development of a produced head, such as occurs with *Uloprora risdonensis* and in species in the genera *Cephalclus* Perch.

and *Paradorydium* Kirk. (Ledridae), has in all three genera, which comprise very small narrow insects, followed the loss of wings and may therefore be correlated with this factor. The effect of head production is to displace the legs from the front part of the body to the centre, and thus possibly serves to adjust the balance for walking purposes of insects that have lost both powers of flight and jumping.

LEDRIDAE

Platyledra monstrosa sp. nov.

(Fig. 4)

Length, 6 mm. General colouration, dark brown. *Head*, ventral surface, ante-clypeus pear-shaped, not separated from the fronto-clypeus by a transverse suture; maxillary plates visible only as a narrow border to the lora, lora apically depressed; fronto-clypeus flattened, separated from the genae by a deep depression; ventral apex of head overhanging, spatulate. Crown, rugose, wide, with three raised prominences close to the posterior border, and with a central longitudinal ridge; ocelli on the crown closer to each other than to the eyes on each side or to the margin of the crown; eyes prominent. *Pronotum* rugose, raised into a hump, wide laterally; propleurae forming overhanging flaps. *Scutellum* swollen apically. *Tegmen* rounded apically, venation reticulate. *Hind tibia*, external surface flattened, bordered by a row of fine even spines.

Type ♂, from King George's Sound, Western Australia, in the collection of the Macleay Museum, University of Sydney.

Ledraprora compressa sp. nov.

(Fig. 7)

Length, 7 mm. *Head*, ventrally pale brown, rugose; fronto-clypeus narrowly produced posteriorly, diamond-shaped in section, tilted dorsally. *Pronotum* brown, mottled with grey posteriorly. *Scutellum* pale brown. *Tegmen* whitish-hyaline, veins brown barred with white. *Thorax* and *abdomen*, ventral surface pale brown.

Type ♀, from King George's Sound, Western Australia, in the collection of the Macleay Museum.

Anacephaleus latus sp. nov.

(Fig. 5)

Length, 4 mm. *Head*, ventral surface pale yellowish-brown; crown pale yellowish-brown with a median longitudinal dark brown stripe. *Pronotum* declivous, wider posteriorly than anteriorly, raised portion dark brown, remainder pale brown. *Scutellum* dark brown. *Tegmen* hyaline, veins pale brown, claval area coriaceous. *Thorax* and *abdomen*, ventral surface pale brownish-yellow.

Type ♂, from King George's Sound, in the collection of the Macleay Museum.

Cephalelus punctatus sp. nov.

(Fig. 6)

Length, 15 mm. *Head* pale brownish-yellow; ventral surface flat from the anterior apex as far as the antennal depressions, thence slightly concave medially. Crown narrowly produced, ocelli closer to the sides of the head than to the eyes. *Pronotum* smooth medially, punctate anteriorly and posteriorly. *Tegmen* punctate, venation distinct, pale brownish-yellow with a wide dark brown band lying close to, but not against, the costal margin; the band extends on to the pronotum and the head. *Thorax* and *abdomen*, ventral surface brown.

Type ♀, from King George's Sound, Western Australia, in the collection of the Macleay Museum.

AUSTROAGALLOIDIDAE

Austroagalloides flavus sp. nov.

(Fig. 8)

Length, 7 mm. *Head*, ventral surface apricot yellow, but for the genae and lora which are pale yellow. Crown narrow, with a broken black stripe along the anterior border. *Pronotum* yellowish-grey flecked with black. *Scutellum* yellow with black markings. *Tegmen* transparent, veins pale pink with small raised white dots; suffused with brown against the hind border between the second cubital and the first anal vein. *Thorax* and *abdomen*, ventral surface, pale yellow.

Type ♀, from King George's Sound, Western Australia, in the collection of the Macleay Museum.

THYMBRIDAE

Mitelloides gen. nov.

The head ventrally is much wider than long, and is bounded posteriorly by an overhanging transverse ridge that borders the fronto-clypeus medially and extends to the eyes on each side. Anterior to this ridge the fronto-clypeus is concave for one-third of its length. The crown is vertical and at right-angles to the ventral surface, and the ocelli, which are on the crown, are closer to the centre line than the eyes on each side. The pronotum is steeply declivous antero-medially, and the tegmina are rounded apically and have very small appendices. The hind tibiae are triangular in section and have a row of six spines mounted on protuberant flattened bases along one edge.

Mitelloides moaensis sp. nov. (Genotype)

(Figs. 9, 10)

Length, 9 mm. *Head*, ventral surface pale yellowish-brown but for the internal margins of the lora and the posterior third of the fronto-clypeus, which are very dark brown. Crown yellowish-brown flecked with reddish-brown. *Pronotum*, anterior two-thirds brownish-yellow with dark brown markings; posterior third grey. *Scutellum* yellowish-brown. *Tegmen*, proximal costal and

claval area punctate, brown, the rest hyaline; veins brown. *Thorax* and *abdomen*, ventral surface pale brown. *Legs* marked with a pattern of brown and yellow. *Male Genitalia* as in fig. 10.

Type ♂, from Moa, Banks Island, Torres Strait (coll. W. McLennan), in the collection of the Australian Museum.

Rhotidoides sidnica sp. nov.

(Fig. 11)

Length, 8 mm. *Head* black evenly mottled with apricot brown, ventrally much wider than long. Transverse ridge at hind margin of fronto-clypeus distinct, extending to the eyes on each side, nearly parallel to the antennal ledges. *Pronotum* and *scutellum* concolorous with the head. *Tegmen* pale khaki with rounded pale yellowish-hyaline markings. *Thorax*, ventral surface and *legs* with dark and pale brown markings. *Abdomen*, ventral surface pale brown. *Male Genitalia* as in fig. 11.

Type ♂, from North Harbour, Sydney (coll. T. G. Campbell), in the collection of the Australian Museum.

BYTHOSCOPIDAE

Trocnada alpina sp. nov.

Length, 7 mm. *Head*, ventral surface, maxillary plates and lora pale grey; fronto-clypeus pale yellow. Crown declivous, pale yellow ornamented with red and black spots. *Pronotum* yellowish-grey with black and pink spots. *Scutellum* yellow with black markings. *Tegmen* pinkish-hyaline; veins pale brown bordered with black spots. *Thorax* and *abdomen*, ventral surface pale greenish-yellow. Hind tibia pale yellow, but for the external surface which is dark brown, and the bases of the spines which are black. *Male Genitalia* with long narrow parameres and sub-genital plates which are concealed by the overlapping tergite of the eighth abdominal segment; pygophores not developed.

Type ♂, from Alpine Creek, Mount Kosciusko (coll. A. L. Tonnoir), in the collection of the C.S.I.R. Division of Entomology at Canberra.

EURYMELIDAE

Eurymelella gen. nov.

This genus is closely related to *Eurymeloides* Kirk and *Eurymellessa* Ev., but the genotype which is described below differs from species in these genera in the following characters: the hind tibiae have only a single spur in addition to several spines, and the sub-genital plates lack any development of a style.

Eurymelella tonnoiri sp. nov.

(Fig. 14)

Length, 5 mm. *Head* black but for the lora, which are in part pale brown, and the crown, which has four white spots. *Pronotum* black, but for the hind

border which is in part white. *Scutellum* black. *Tegmen* black with irregular hyaline areas, veins brown; a narrow sinuate white fascia stretches diagonally from close to the junction of the radius and media to the second anal vein. *Thorax* and *abdomen*, ventral surface and *legs* marked with an irregular pattern of black and brown.

Type ♂, from Alpine Creek, Mount Kosciusko (coll. A. L. Tonnoir), in the collection of the C.S.I.R. Division of Entomology at Canberra.

***Eurymeloides kalimensis* sp. nov.**

(Fig. 13)

Length, 7 mm. *Head*, *pronotum* and *scutellum* pale brown mottled with dark brown. *Tegmen* hyaline brown with two transverse white fasciae. *Thorax* and *abdomen*, ventral surface with light and dark brown markings. Hind tibia pale brown, each spur dark brown at the apex white at the base.

Type ♂, from Kalima, in the collection of the Australian Museum.

***Ipoides maculosa* sp. nov.**

(Figs. 15, 16)

Length, 7.5 mm. *Head*, width 3 mm. *Head*, *pronotum* and *scutellum* pale yellowish-brown mottled with black, or largely black; eyes, dark red. *Tegmen* marked with a variable pattern of black and whitish-hyaline; two transverse hyaline fasciae may be developed. *Thorax* and *abdomen*, ventral surface pale brown. *Legs* black, the edges white or pale brown.

Type ♂, from Frome Downs Station, South Australia (coll. D. C. Swan, 4/38 on *Heterodendron* sp.), in the collection of the Australian Museum.

***Ipoides loranthae* sp. nov.**

(Figs. 17, 18)

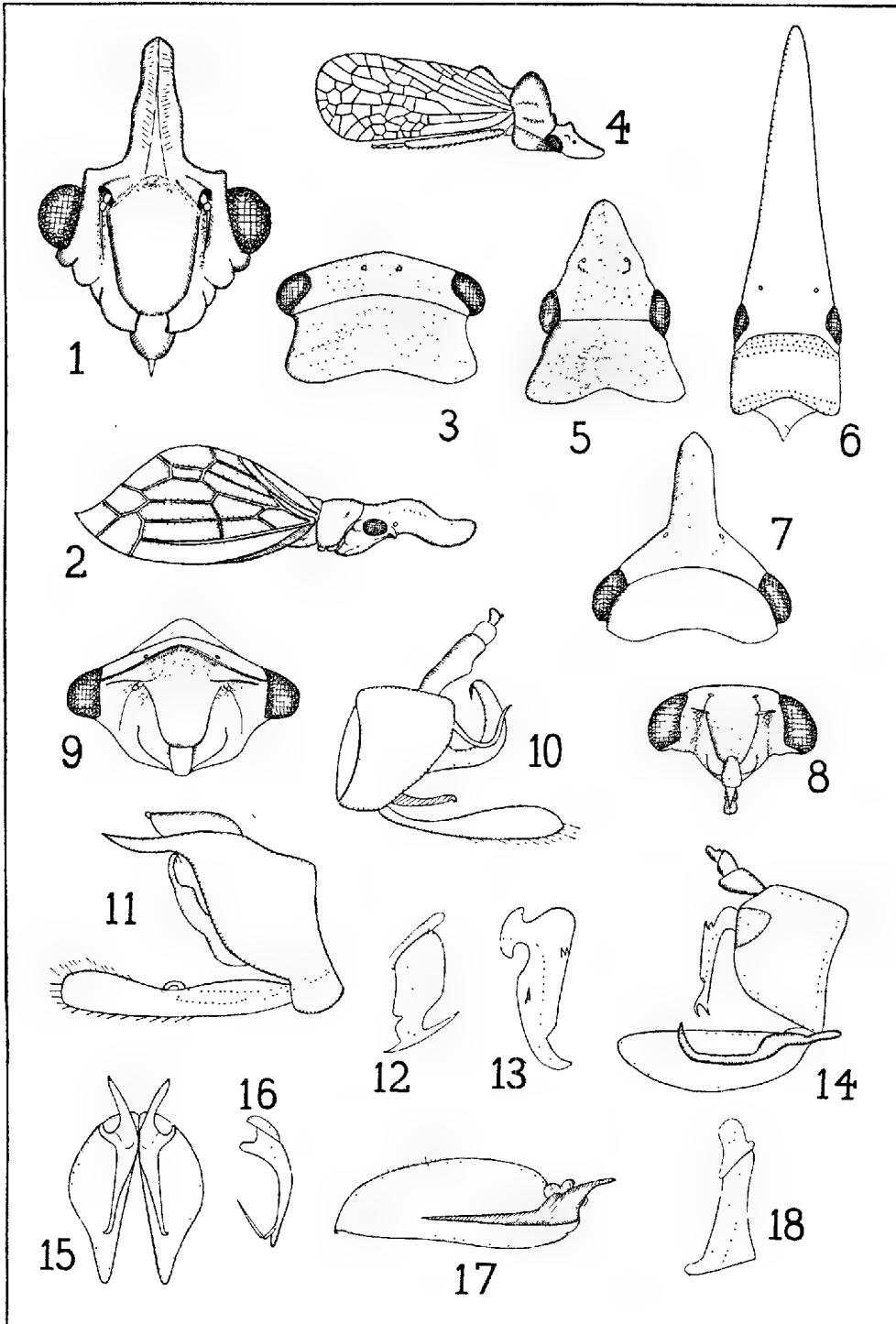
Length, 5 mm. *Head*, maxillary plates and lora whitish; ante-clypeus and fronto-clypeus medially black mottled with pale yellowish-brown; vertex marked with a pattern of black, light and dark brown. Crown of head and *pronotum* concolorous with the vertex. *Scutellum*, anterior angles black, the remainder black mottled with brown. *Tegmen* hyaline, veins black with white bars; claval area brown with two irregular white markings. *Thorax* and *abdomen*, ventral surface, pale brown.

Type, ♂, from Curnamona Station, South Australia (coll. D. C. Swan on *Loranthus pendulus* growing on *Eremophila glabra*), in the collection of the Australian Museum.

***Ipoella norrisi* sp. nov.**

(Fig. 12)

Length, 6 mm. *Head* pale biscuit-colour with or without black or brown markings on the fronto-clypeus and vertex. *Pronotum* pale brown or black mottled with grey. *Scutellum* marked with an irregular black and brown pattern.



Tegmen pale hyaline-white partially suffused with light or dark brown, and with small anterior and posterior white fasciae that do not extend as far as the anal border. *Thorax* and *abdomen*, ventral surface pale brown.

Type ♂, from Fremantle, Western Australia (coll. K. Norris), in the collection of the Australian Museum.

DESCRIPTION OF FIGURES

Figs. 1-18

1, *Uloprora risdonensis*, head, ventral aspect; 2, *Uloprora risdonensis*; 3, *Austrolopa victoriensis*, head and pronotum, dorsal aspect; 4, *Platyledra monstrosa*; 5, *Anacephaleus latus*, head and pronotum, dorsal aspect; 6, *Cephalelus punctatus*, head and pronotum, dorsal aspect; 7, *Ledraprora compressa*, head and pronotum, dorsal aspect; 8, *Austroagalloides flavus*, head, ventral aspect; 9, *Mitelloides moacensis*, head, ventral aspect; 10, *Mitelloides moacensis*, male genitalia; 11, *Rhotidoides sidnica*, male genitalia; 12, *Ipoella norrisi*, aedeagus; 13, *Eurymeloides kalimensis*, aedeagus; 14, *Eurymelella tonnoiri*, male genitalia; 15, *Ipoides maculosa*, sub-genital plates and parameres; 16, *Ipoides maculosa*, aedeagus; 17, *Ipoides loranthae*, sub-genital plate and paramere; 18, *Ipoides loranthae*, aedeagus.

THE HUMAN FIGURE IN PAPUAN SPATULA DECORATION

By R. MURRAY BERNDT

Summary

The Melanesian, in using and decorating the Lime Spatula, has contributed much to the world of art. These attractive small objects, the Papuan spatulas, are used in conveying lime to the mouth from gourds.

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[Read 11 May 1939]

INTRODUCTION

The Melanesian, in using and decorating the Lime Spatula, has contributed much to the world of art. These attractive small objects, the Papuan spatulas, are used in conveying lime to the mouth from gourds.

As a rule the design is incised and filled in with lime, giving a contrast to the black ebony wood from which the stick is usually made. Many of the designs are peculiar to certain areas. Haddon (1894, p. 203) mentions that the older the specimen, the better generally is the carving, and nowadays there is a tendency for them to be turned out quickly, as time means money, even to these people, who sell their work to anxious buyers. Consequently, degeneration in artistic excellence has set in under white man's influence, the natives now being in many cases content with undecorated utensils. At the present time most of the old and well-carved objects have gone, and the natives find that the trader does not insist upon perfection.

In the carving of a spatula's head, the native artist has let his fancy have full play and consequently numerous variations occur in any one design copied, while different stages of conventionalisation appear.

The artist has not attained the stage of the pure realism of the classical civilizations, because his approach, both aesthetically and psychologically, is limited by the traditional background he is bound to follow. Consequently, the motif and treatment are altogether different from those of our own. The essential significance of each object lies in the ritual and social life of the artist who gave it being.

Miss Reichard (*Melanesian Design*, 1933) states that as a result of her studies she has observed that "one of the most obvious features of cultural phenomena is the fact that each is cast in a particular mould. So characterising is this mould in the case of art that most objects bear the stamp of the culture in which they were made as surely as our own paintings carry the signature of their makers, either directly or in the peculiarities of an individual style."

DISTRIBUTION

The specimens illustrated in this paper are usually met with in the islands of the archipelagoes off the south-east of New Guinea. In the description of each individual piece (the drawings of which are from the originals in the South Australian Museum collection) the locality from which each was collected is given, and can be traced on the accompanying map (fig. 1), so that an area for this type is established.

Haddon (p. 184) states that the human-headed spatula came from Massim, a conventional name for the coastal area from Pouro (Mullen's Harbour) to Baunia (Bartle Bay) and to all the islands from D'Entrecasteaux to the Trobriands and the Louisiades.

The inhabitants of this archipelago, as is generally the case, are great traders and travellers. The smaller articles of barter are widely distributed, and many of these, such as lime spatulas and gourds, which are usually ornamented, consequently tend towards a uniformity in design within this area.

Haddon (p. 185) states that lime gourds and spatulas from the Trobriand Islands are traded to the mainland, and have been mistaken for indigenous productions, and that (p. 211) while this human motif extends also to Woodlark Island, it has probably originated in the Trobriand Group.

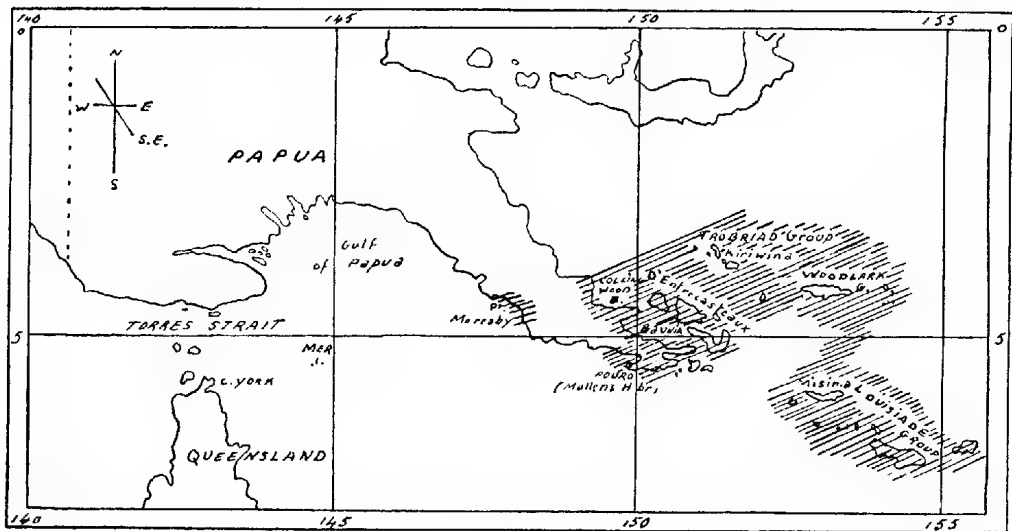


Fig. 1

Map showing the distribution of the human figure in Spatula decoration on the south-east coast and archipelagoes of New Guinea

Examples (in the South Australian Museum) described in this paper are from North Massim, Kiriwina (Trobriands), Lake Kenu, Misima Island (Louisiades), and Collingwood Bay (south-east coast, New Guinea), while one specimen was from Port Moresby.

The shading on accompanying map (fig. 1) gives the distribution of the lime sticks as far as can be ascertained with any accuracy.

DECORATION AND DESIGN

The artistic development of the anthropomorphs is considered here, in its various forms of primitive inspiration and interpretation.

There is a great diversity in the character and features of these carvings. The legs may be present or entirely absent; the arms may be prone or fixed; the

hands be placed on the abdomen, on the chest or held up or alongside, and sometimes underneath the chin.

In fact the different postures of the figure's limbs vary, so that two objects are seldom exactly alike. Yet each one is individual, reflecting the native artist's mood. Each is an object of primitive art, bound down by a traditional code, from which the carver does not break away. Within it lie his beliefs, both ritual and social.

McCarthy (p. 17) in his introduction to "Australian Aboriginal Art," states, "the origin of art lies in man's innate sense of beauty, as is illustrated by the existence of some type of art, be it ever so crude or elementary, in every community of human beings. In primitive society an important element of culture is produced by uniting the desire for aesthetic expression with an inspiration which is of social benefit, and art is thus brought into a social and ritual mechanism from which it cannot be viewed in disassociation."

In the following illustrations one is struck by the excellence of carving and individuality, while the trends of different "schools" of art-craftsmen can be traced.

As to the possible clue to the meaning of each representation, it is difficult to conjecture. Only through questioning the native, and studying the ritual and social life of the community, can its determination be made.

Many figures are possibly of ceremonial character and may act as totems; others are perhaps mere caricatures of associates and fellow-tribesmen, while the figure in haunched position has a very ancient origin, having its prototypes in many parts of the world. Boyle (p. 186) says that this human haunched figure plays a great part in the artistic development of most primitive races. He also notes that, in the mythology of Melanesia and Polynesia, the natural posture of man before his gods is this squat or haunched attitude, this conception probably having its origin in earliest antiquity.

DESCRIPTION OF ILLUSTRATIONS

The following illustrations are arranged so as to show the progression from the naturalistic to the conventional form.

Fig. 2, A. This specimen was collected on the south-east coast of New Guinea. The two human figures back to back, with conventionalization of the limbs are noticed, the hands are held to chin, whilst the legs have been stylized as circles.

The barrel of this stick begins with a human face or mask seen at the end of middle drawing, and terminates in (a), while the usual end (b) brings it to its full length. The attached decorations are of red trade glass beads, coral discs, black hollow seeds, and cut pearl shell ends, threaded together on fibre.

The six following animated carvings are of the realistic or naturalistic school. The distribution of these extends over the same area, and constitutes the work of the few native artists who had somewhat broken away from the traditional code laid down by their forefathers.



Fig. 2

Spatula head decoration in the human motif
 A, Conventionalized B-J, Realistic K, Intermediate

It is interesting to follow the development of this branch of their art. Some examples bear passable comparison with the art of the Western world; in fact, the carvings are of excellent workmanship.

Fig. 2, B, is of no definite locality, other than New Guinea. It is almost ancient Egyptian in aspect; its modern facial appearance, clasped hands held on the chest, and the ribs heightened by lime inlay on the blackwood, leaves a plain body with the peculiar leg adjustment.

Fig. 2, C, is the profile of the last. The treatment of the shoulder to the curve of the back is shown, with loop under chin.

Fig. 2, D, from Collingwood Bay, North Massim, is carved from light palm wood. The head, well set upon the shoulders, gives a typical native appearance. The arms are crossed upon the chest, and the figure sits in the haunched or squat position.

Fig. 2, E, is the side view of the last. Notice that the figure in profile is altogether different from when viewed from the front.

Fig. 2, F. This excellently carved haunched figure in blackwood, from Misima Island, Louisiade, has its hands under a rather square and aggressive chin.

Fig. 2, G, from North Massim, is an interesting figure in the haunched position, the hands to chin, showing an attempt at carving the overlapping fingers of the clasped hands. The head is perfectly balanced, having a curious eye decoration, a hole through the nose, and the forehead ornamented in scroll design.

Fig. 2, H, was collected at Lake Kemu, and is a squat human figure, with animal-like head, which is probably a mask worn by the native. Ornamented ears, pierced to take decoration in the form of beads, etc., circle eyes, and long head with nostrils, give an extraordinary type of motif, which is purely naturalistic except for the traditional posture of the legs. It is strangely reminiscent of the animal-headed gods of ancient Egypt.

Fig. 2, J, of no definite locality, is a full-length carving. Conventionalization has taken place with the arms and legs. The face has a humorous touch.

Fig. 2, K. (from Edge-Partington, p. 312) gives an intermediate stage with a realistic head and conventionalized limbs.

Fig. 3, A, from the south-east coast, is the first really conventional type, and at this stage one can still understand the full idea of body representation on traditional lines. It has not lost any of its essential outlines, as is the case with others illustrated, which do so gradually until the extreme is reached, that is, the human aspect is always perceivable.

Fig. 3, B, collected at Port Moresby, is a front view, showing a meandering design down the centre of the body.

Fig. 3, C, side elevation of last, an elongated type of 3, A. This traditional type being ornamented, the scrolls follow the contour of the figure's arms and legs.

Fig. 3, D. The evolution of conventionalization has been carried one step further in this spatula from North Massim. The two figures (as in fig. 2, A), back to back, are set on an extraordinary piece of carving which will be dealt with later (compare fig. 5).

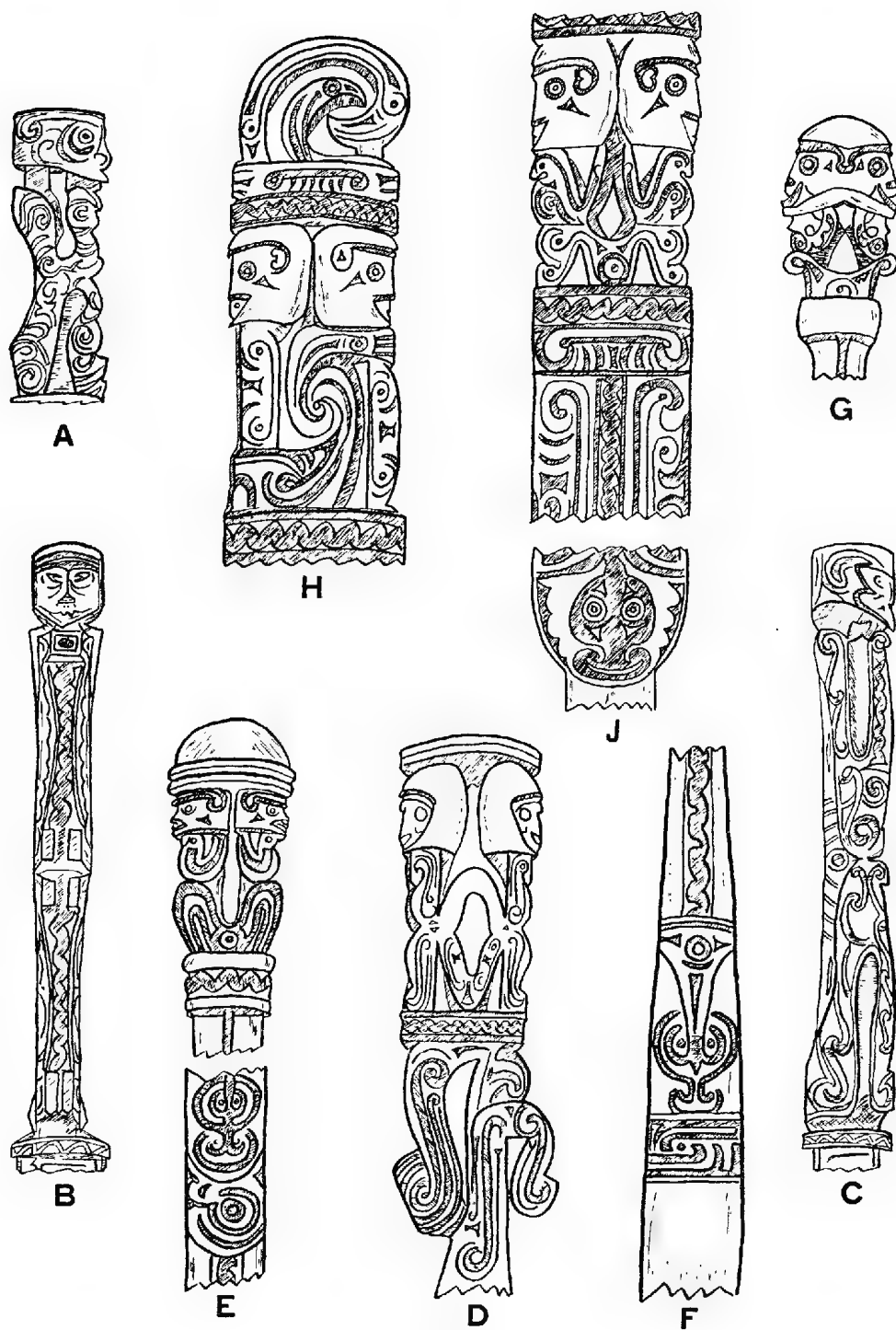


Fig. 3

Conventionalized Spatula heads (Traditional type)

A-C, Single figure D, E, G, and J, Double, with H Extreme stylizing of limbs

In fig. 3, E, F, from Misima Island, Louisiade Group, a variation of the last (3, D) is noticed. The main shaft (F) of the lime stick is decorated with mask and meandering pattern.

Fig. 3, G. In this small carving from Lake Kemu, the two heads, as well as the leg formation, have become one, and so lost their separate individuality, as seen in the previous two specimens (3, D and 3, E).

In fig. 3, H and J (from same locality as the last), an altogether beautiful carving is produced. It is interesting that on the same stick, the curl-like design dominates the crest, with a double head decoration, showing extreme conventionalization of the body; while directly underneath, (J), the more standardized type (see 3, D and E) occurs, with a large quantity of incising further down, terminating with a mask.

In the following single ones the evolution of the body is more noticeable.

Fig. 4, A, from Misima in haunched posture, has the front legs extended a little down the shaft of the spatula. The head is topped with a carved crest.

Fig. 4, B, from the above locality, illustrates a further stage. The body has developed into a fish-hook design (compare fig. 5, E).

While in fig. 4, C, collected at North Massim, the legs are almost spiral. The head has received curious treatment, in a cap form, the eyes peering out from beneath this peak.

From Lake Kemu comes fig. 4, D. Two features are striking, the face treatment and the disappearance of the lower limbs, leaving only the shoulders and arms.

Fig. 4, E, of no definite locality, has a leaning effect, and is decorated with scrolls. It is probably the figure's body, welded into one and thus becoming a solid, without featuring of limbs. A piece of straw binds the base of the carving.

Fig. 4, F, is carved in a light brown wood, and is from Kiriwina, Trobriands.

It is treated in somewhat the same manner as fig. 4, D, and wears a scroll-like head-dress from its back to top of head.

Fig. 4, G, from North Massim, is a figure carved in the traditional style, beautifully scrolled all over the body, and wearing a crest.

Before passing this point it is advisable to review the previous illustrations, and note that the main representation in both the conventional form, as well as in the naturalistic, is the haunched posture; its use and meaning are believed to be unknown. It is from this peculiar attitude that many designs, as suggested here, have been inspired.

In fig. 4, G, is shown a specimen with a crest worn at top of head. In arriving at a probable solution of this symbol or design, it is interesting to notice that the same ornament (5, E) is found sometimes alone on the spatula, and can be linked up with a series of turtle-shell ornaments (called *sabagorar*) illustrated by Haddon (p. 33, fig. 12, H, D, E, and C) and probably derived from fish-hooks. This author also states that they are worn in the Torres Straits, but suggests, however, that the design is derived from a more ancient idea and that



Fig. 4

Single figures, illustrating degrees of conventionalization and body decoration

the ornament of varying form belonged to the girls and formed part of their marriage outfit; this was certainly the case at the Island of Mer, and extended through the Straits to along the Coast of New Guinea Archipelagoes.

COMPARISONS

Compare designs in fig. 5. F is a crest from North Massim, and is very near D and C, which are the fish-hook charms. E is a more highly ornamented example. B is a double fish-hook which probably inspired the crest design of 4, A (which is turned upside down). Also compare the fish-hook design with the conventionalized limbs of the human figure, 4, B.

This spiral symbol perhaps has some definite connection with the male human figure as illustrated (fig. 4, G) and may represent a motif of ceremonial intent, as the two designs are used together on the figure.

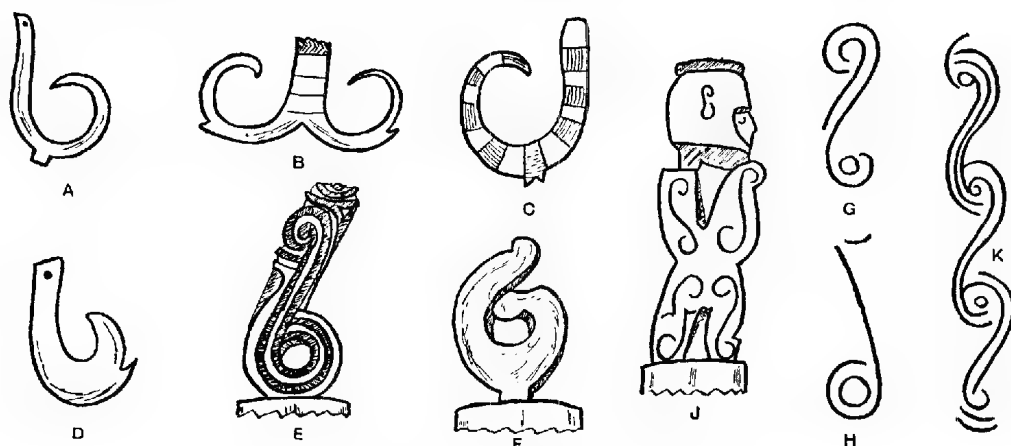


Fig. 5

Fish-hook, crest, scroll and meander designs

Whilst making comparison of this spiral design, it has already been stated that its representations have appeared in many parts of the world, and much has been written of it; no attempt is made here to analyse it with any degree of completeness, but merely to note a few points which occur in this paper.

Elliot Smith (1924, p. 3) gives a chart showing the diffusion of culture from Cambodia along whose routes, passing through Indonesia, Micronesia and Central America, and the southern route through Melanesia to Polynesia, the spiral or fish-hook ornament appears.

He states (Elliot Smith, p. 7) that this spiral has appeared on designs in which the elephant has been connected as an irrelevant addition, but that actually it is an arbitrary convention found in certain ancient representations of this animal and the mythical elephant fish (*makara*) in India and Eastern Asia.

This *makara* (Elliot Smith, p. 57) manifests itself in an amazing variety of forms, some of which are interesting as links with the mythologies of countries remotely distant.

The sea-elephant is described as "a creature formed of the fore-part of an elephant with the body and tail of a fish." In Eastern Asia (Elliot Smith, p. 67) these mythical creatures assume a variety of forms, crocodile, shark, turtle or tiger being, respectively, the obtrusive ingredient in the composite animal in different specimens. The dragon is a derivation of this, as also may be the shark or the crocodile conventionalized design, in which the spiral appears (Berndt, 1939) commonly in Melanesia, especially along the south coast of New Guinea.

This crocodile design is composite, its spirally coiled tail nearly always appearing in decoration, and, when highly conventionalized, has become almost a separate identity.

In some representations of the crocodile in Melanesian art, notably the arrow design (Edge-Partington, p. 267, fig. 7), a human head is noticed emerging from the reptile's jaws. Elliot Smith (pp. 76-79) gives examples of this myth of the "Jonah incident" occurring in India, Eastern Asia, China, Japan and Central America. Hence possibly its association with the human figure in the spatula decoration, and the wearing of the spiral as a crest.

It is known that crocodile and shark cults existed, and still exist, along the south coast of New Guinea and Torres Straits (Haddon, 1894, p. 201).

One may here note the coincidence of the occurrence in Australia of the crocodile carving at Panaramittee recorded by Mountford (1929, p. 245), and now in the South Australian Museum.

There is a constant use of the spiral or the concentric circle in Australian aborigine art, it often being interpreted as a symbol for waterholes (Mountford, 1937, in his aborigine crayon drawings from Warburton Ranges, Western Australia, pp. 22, 23). Hence two examples of the aquatic associations in force in Australian art.

It is also interesting that the horn on the side of the fish-hook charms (Fig. 5, D, C, and B) may possibly have association with the elephant-*makara*, many examples existing with the horn in crocodile derivations.

It has already been stated, when describing the animal-like spatula head (fig. 2, H), that it has some resemblance to the animal-headed gods of Ancient Egypt, India and Eastern Asia. We know of the crocodile-headed god Sebek of Egypt, who was a water-god, and Ammon wearing as a crest the spiral-horned ram. But this spatula, half man, half animal, has the manifestation of a composite being. The elongated head with an elephant-like trunk, large unusual-shaped ears, and concentric circled eyes, is apparently worn as a head-dress, with the human body in traditional posture.

Many comparisons could be made in the above-mentioned designs, but the most outstanding have been put forward, and open up interesting paths of discussion as to the probable origin of the fish-hook spiral, with its connection to the human figure, and association in crocodile designs.

There is an outstanding difficulty which appears in linking up the spiral derived from the *makara* with that evolved from the conventionalized lower limbs of the human figure of the spatula head, illustrated in fig. 4, B.

When one considers the evolution of this figure in haunched position, to its eventual spiral form in 4, C, there is a doubt as to this connection.

Whether it has originated quite separately and independently of any outside influence in decorative schemes, and whether we are to consider the human figure apart from this fish-hook spiral, or that the crest is not derived from the contour of the human form in this area (New Guinea) is yet to be proved.

An attempt is made in this paper to trace this design from the contour of the squat human figure's conventionalized limbs.

Fig. 4, H, is a figure from North Massim, and is inserted here for its scroll work, inlaid with lime, on the squat body. This design is known as the scroll or bird motif.

Haddon (p. 199) places it as the bird motif, which found its way along the western and south-eastern limits of the coastline, while the central district is practically devoid of this scroll. He has no direct evidence as to what the bird is that is so constantly depicted, or actually that it is a bird at all.

He bases his argument on the frigate bird which is the emblematic bird of the western Pacific, and is regarded as being very swift and a powerful aid at sea, as well as its attribute of drawing the canoe quickly and surely to the land.

But it may quite likely be inspired by the contour of the limbs (fig. 5, J), as it follows out the arm and back position as well as the leg and haunched effect (fig. 5, G and H).

This may, however, be derived also from either source, as one locality will so conventionalize an original motif that it becomes almost the same as the other.

From the scroll or bird design a series of looped scrolls develop, as in fig. 5, K, probably evolving the meandering scroll as in fig. 3, B.

SUMMARY

The above descriptions are of Papuan and New Guinea Archipelago lime spatulas, and illustrate the trend in both realistic and conventionalized examples—namely, that of the traditional type, the haunched figure.

In choosing this special type from the varied carvings found on the heads of these interesting utensils, it is suggested here that many of the fundamental designs and decorative schemes used in Papuan ornamentations of their different objects are derived from the human figure, especially in the squat position.

It has been with that object in view that an evolution of this type of spatula head has been given.

Thus are shown the ultimate designs, such as the "fish-hook," "crest," "frigate bird," "scroll," and "meander" types possibly derived.

Some early forms of this spiral are noted, with comparison in design, with possible "makara" significance and connection with the spatula decoration.

The naturalistic and conventionalistic styles are compared.

TABLE OF SPATULA MEASUREMENTS
of those described and illustrated in this Paper

Text Figure	Letter	Length of Head of Stick	Length to End of Carving	Total Length
2	A	—	24 cm.	48 cm.
	B	11.5 cm.	—	29
	C	11.5	—	29
	D	13.5	—	29
	E	13.5	—	29
	F	12	—	36
	G	14	—	34
	H	15	—	27
	J	13	—	24
	K	none given	—	none given
3	A	9.5	—	27
	B	18	—	43
	C	18	—	43
	D	13	—	26
	E and F }	7	39	49
3	G	5.5 cm.	—	35.5 cm.
	H and J }	—	41 cm.	74
4	A	14	—	33
	B	6	—	28.5
	C	7	—	21
	D	10	—	52
	E	7	—	23
	F	15	—	33
	G	21	—	53
	H	15	—	57
5	E	5	—	—
	F	5	—	—

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LARVAL TREMATODES FROM AUSTRALIAN TERRESTRIAL AND FRESHWATER MOLLUSCS PART V

By T. HARVEY JOHNSTON and E. R. SIMPSON, University of Adelaide

Summary

Cercaria parocellata n. sp.

Though large numbers of *Limnaea lessoni* from the lower Murray River swamps have been examined, only one has been found to harbour *Cercaria parocellata*, the snail being collected at Swan Reach on 7 December, 1938. It died on 6 January, 1939, during excessively hot weather, and partial disintegration had taken place before it was preserved. This accounts for our failure to find complete sporocysts, though there were recovered thin empty portions and shorter thick parts containing germ balls and cercariae, some of the older more attenuated sporocysts showing the presence of orange granules in the walls.

LARVAL TREMATODES
FROM AUSTRALIAN TERRESTRIAL AND FRESHWATER MOLLUSCS
PART V

By T. HARVEY JOHNSTON and E. R. SIMPSON, University of Adelaide

[Read 11 May, 1939]

***Cercaria parocellata* n. sp.**

Figs. 1-7

Though large numbers of *Limnaea lessoni* from the lower Murray River swamps have been examined, only one has been found to harbour *Cercaria parocellata*, the snail being collected at Swan Reach on 7 December, 1938. It died on 6 January, 1939, during excessively hot weather, and partial disintegration had taken place before it was preserved. This accounts for our failure to find complete sporocysts, though there were recovered thin empty portions and shorter thick parts containing germ balls and cercariae, some of the older more attenuated sporocysts showing the presence of orange granules in the walls.

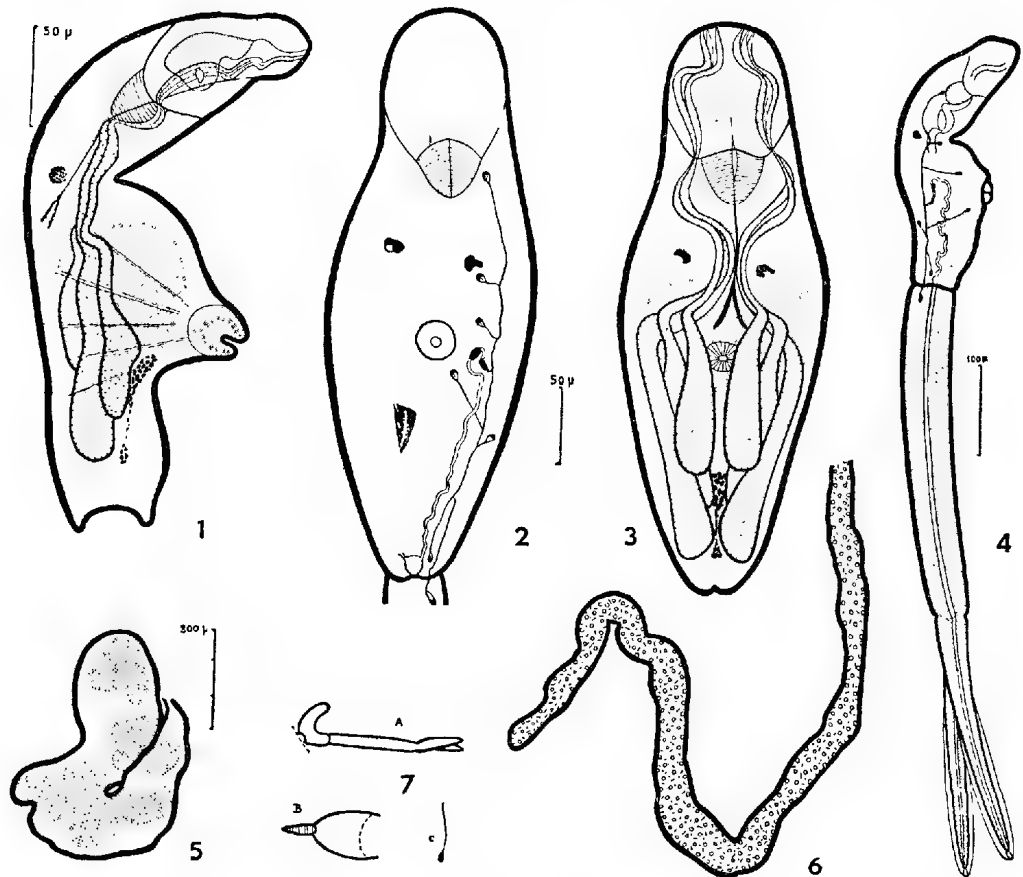
The cercaria was positively phototropic, spending most of its time resting attached to the lighted side of the glass receptacle, but sometimes rising to the surface of the water. The resting position was characteristic (fig. 7A), the ventral sucker being thrust well forward and serving for attachment while the head region was bent backward to form an open U with the rest of the body, the tail floating out with its furcae close together or slightly crossed. When swimming a shimmering effect was produced, the cercaria moving rapidly with an irregular spinning motion and occasionally resting with the head hanging almost vertically downwards (fig. 7C), so that the organism resembled somewhat a long-handled spoon.

The average measurements of fourteen formalinised specimens were: Length of body, 282 μ ; breadth of body, 54 μ ; length of tail stem, 362 μ ; length of furcae, 250 μ ; length of anterior organ, 89 μ . The body was covered by numerous small, uniformly arranged spines, but there were no special head spines. The anterior organ was subdivided, the posterior portion being very muscular, while the anterior contained a large granular head organ with a prominent nucleus. The mouth lay ventrally on the anterior organ, and the gut was traceable as a thin line, dividing behind the level of the eyes into two short caeca. The large eyes consisted each of an aggregation of dark granules, a lens apparently being present on the ventral side of it.

The small, completely retractile ventral sucker was not provided with special hooks. The organ was usually thrust out so that most specimens appeared in side view on the slide. In formalinised material, a characteristic bend was (fig. 1) seen on a level with the eyes, the protruding sucker lying behind this region. Large muscle bands extended from the sucker to the dorsal region of the body.

The tail possessed well-developed muscles and numerous caudal bodies, the latter not readily seen. The furcae were provided each with a membranous distal fold, interrupted at the tip by the end portion of the excretory tube.

The gland cells were arranged in two groups, an anterior of two pairs of large, coarsely granular cells, and a posterior of three pairs of finely granular



Figs 1-7

Cercaria parocellata. Fig. 1, side view; 2, excretory pattern; 3, front view, specimen slightly extended; 4, whole mount, side view showing excretory system; 5, 6, portions of sporocysts; 7 A, resting position; 7 B, swimming; 7 C, suspended.

Figs. 1, 3-6 drawn with the aid of a camera lucida; figs. 2 and 3 drawn to same scale, the remaining figures to the scales indicated beside them.

cells. Their ducts followed a characteristic course (figs. 1, 3), passing through the front portion of the anterior organ to open each on a slight projection.

The gonads were represented by a large group of darkly staining cells, just posterior to the ventral sucker. Connecting this group with a smaller, more posterior group was a string of cells.

From the small excretory bladder, each main tubule passed forwards to about the level of the ventral sucker, where it formed a loop with two ciliate areas and then gave rise to an anterior and a posterior collecting tubule. There were six pairs of flame cells in the body, three cells connected with each anterior and three with each posterior tubule; and also one lying at the base of the tail (figs. 2, (4)). The main excretory tubule passed down the centre of the tail, bifurcating into the furcae to open at the tips of the latter through a small, almost bladder-like extension of the tube in the membranous fold of the corresponding furcae.

Our cercaria belongs to the schistosomes and falls into Miller's (1926) group D (*clvæ* group) of apharyngeal brevifurcate distome cercariae, and into Wesenberg-Lund's (1934) *ocellata* group. It differs from the only adequately described Australian schistosome larva, *C. jaenschi* Johnston and Cleland (1937), in possessing one more flame cell attached to each posterior tubule, and in some other features. Its nearest known ally is *C. ocellata* La Val. Wesenberg-Lund (1934) gave a list of European cercariae belonging to this group, together with a description of *C. ocellata* and of the cercaria of *Bilharziella polonica*. From the latter our species differs in the relative dimensions and in the structure of the tail; *C. macrosoma* Brown (1926) possesses a different number of gland cells; while *C. echinomorpha* Brown (1931) differs in the length of body (150μ) and furcae (120μ) and in the non-differentiation of gland cells.

The measurements of our formalinised specimens fall within the range of those given for *C. ocellata*, except for the length of the anterior organ which averages 89μ in the Australian cercaria, but is stated by Wesenberg-Lund to be between 37 and 56μ in the Danish form; in the latter, this author did not observe body spines. *C. clvæ* Miller (1923, 38; 1926), which is perhaps identical with *C. ocellata*, appears to be a larger cercaria than the latter (though Miller [1926, 31] stated that the former was smaller) and the Australian species. Measurements given by Miller for balsam mounts of the North American form are: Body, 368 by 41μ ; tail stem, 382μ ; furcae, 290μ ; and anterior organ, 96μ in length.

Although the differences between *C. ocellata*, *C. clvæ* and our form are slight, we consider it preferable, until the full life cycle is known, to regard the last mentioned as distinct, and have accordingly named it *C. parocellata*. Attempts to infect a young muscovy duck with it have been unsuccessful. *C. ocellata* is the larva of *Trichobilharzia ocellata*, a blood parasite of ducks.

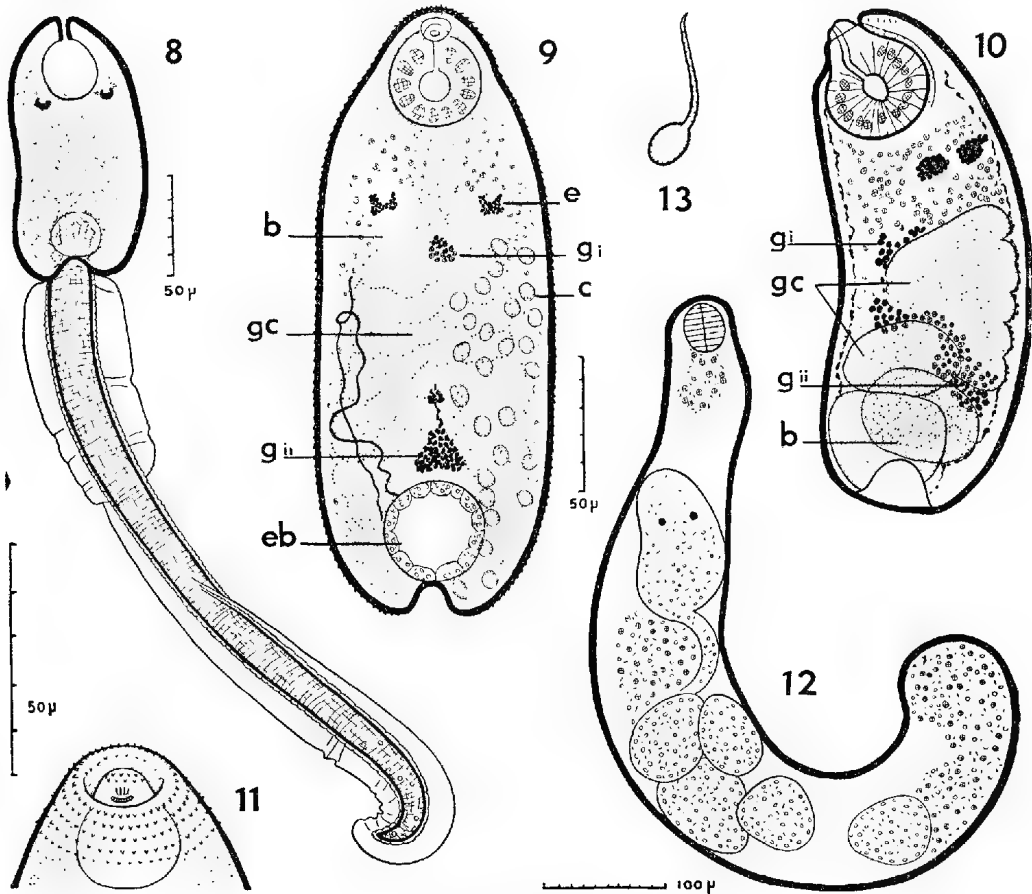
***Cercaria plotiopsis* n. sp.**

Figs. 8-13

A species of heterophyid cercaria was given off from eighteen of 519 specimens of the Melaniid gastropod, *Plotiopsis tatei* (Brazier), collected in December, 1937, and from eighteen of 370 taken in December, 1938, all of them from Swan Reach, Murray River. The infection rates were thus about

3.4 and 5%, respectively. The larvae were clearly seen suspended upside down in the water as they sank slowly, or as they regained their position by abrupt jerky upward movements. When resting, their position was characteristic (fig. 13), somewhat resembling a spoon with a curved handle. The cercariae were positively phototropic.

The measurements of ten formalinized specimens were as follows: Length of body 110-144 μ , mean 126 μ ; breadth of body 51-76 μ , mean 68 μ ; mean length of anterior organ, 26 μ ; mean breadth of anterior organ, 23 μ . The body,



Figs. 8-13

Cercaria plotiopsis. Fig. 8, ventral view; 9, body, ventral view; 10, body, side view; 11, head region; 12, redia; 13, resting position of cercaria.

All figures drawn with the aid of a camera lucida. b, brain; c, cystogenous cells; c, cyspots; eb, excretory bladder; gi, gii, genital rudiments; gc, gland cells.

especially the fore part, was capable of very marked contraction and expansion. The main colour was pale brown, and superficial brown pigment granules were distributed as a network near the surface and especially aggregated around the bladder and eye spots. The latter were large and composed of a rectangular cup-shaped group of dark brown granules in the vicinity of the H-shaped brain.

The small, slightly curved body spines were arranged in rows, giving a finely wrinkled appearance to the cercaria. The spines were larger at the anterior end. In front of the spiny region was a circumoral spineless area capable of great retraction, so that the lip and the mouth could be withdrawn as though into a hood. The anterior end of the animal was not retractile. The mouth opened ventrally, had a chitinous rim, and along its upper surface were four narrow chitinous bands. Two rows of spines, the anterior containing six and the posterior five, were situated on the lip in front of these bands. The anterior organ was large. No trace of a digestive system nor of a ventral sucker was recognised. Numerous cystogenous cells were present in the body.

There were seven pairs of large lobed glands with well-defined nuclei, the cells extending from behind the eyes to the posterior end of the body. The anterior three pairs met in the centre, while the most posterior glands were arranged two on each side of the bladder. Coiled ducts passed forwards in the vicinity of the median line, and then on either side of the anterior organ, to open separately on the circumoral spineless area.

The conspicuous bladder lying at the posterior end was bounded by large cells. From it a fine excretory canal passed forward on each side, reaching a point between the second and third gland cells, where it subdivided into ascending and descending ducts. The former was traced to the level of the eyes, and the latter as far back as the level of the bladder. Flame cells were not recognised.

The tail was about $360\ \mu$ long, curved, and in side view slightly S-shaped. It had well marked longitudinal and circular muscle fibres, as well as a group of large nuclei near the tip. There were two series of membranous transparent fin-folds; an anterior lateral pair arising from the base of the tail and extending backwardly for nearly one-third of its length; and a posterior dorso-ventral fold commencing on the dorsal side just above the end of the lateral folds and extending back to the tip of the tail to become continuous with a shorter ventral fold. These fins were at times thrown into a series of folds, at first sight resembling fin-rays. Sewell (1922, 26) pointed out that such appearances were due to the contractility of the tail and vanished when the membrane was extended.

The short, usually curved, thin-walled redia at first sight suggested a sporocyst. The pharynx was succeeded by a very short gut, not readily seen. The cavity of the redia was filled with germ balls, generative tissue and developing cercariae. Mature rediae sometimes showed one or more constrictions in the distal portion of the body.

In order to obtain the encysted stage of the trematode, attempts to infect the following fish were made without success: golden carp (*Carassius auratus*), rice fish, *Pseudomugil signifer* Kner and *Melanotaenia nigrans* Richardson.

Our cercaria belongs to the Heterophyidae and very closely resembles that of *Monorchotrema taihokui* and *M. taichui* Faust and Nishigori (1926). From the latter our species does not appear to differ in any essential details. The number and arrangement of the gland cells, as well as the form and spination of the

anterior end are similar, while the body size of the Japanese form falls within the range of that of the Australian cercaria. The separation of the fin folds into lateral and dorso-ventral groups was not noted by Faust and Nishigori, but was noted by Sewell as occurring in his *Cercaria indica* vii. We failed to find a ventral sucker in our material. The bladder in our species resembled that described by Sewell for his cercaria (1922, 25) and appears to represent in shape and position the structure labelled ventral sucker in the figures (Faust and Nishigori, fig. 14) of the Japanese species. In the illustrations of the adult *Monorchotrema*, a ventral sucker is shown as lying anteriorly to the testis yet in the larva it is indicated as being posterior to that organ. In view of these discrepancies it seems likely that the organ labelled as sucker in the larva is really the excretory bladder, similar to that indicated in their fig. 20. From *Cercaria indica* vii our species differs in the number and arrangement of the gland cells.

In view of the lack of knowledge of Australian adult heterophyids, we prefer to attach a distinctive name to it, ***Cercaria plotiopsis*** n. sp., after the name of its host mollusc.

This series of investigations has been made possible by the Commonwealth Government's research grant to the Adelaide University.

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THE FIRST STAGE OF THE ADELAIDE SERIES: AS ILLUSTRATED AT MOUNT MAGNIFICENT

By D.MAWSON

Summary

Of the rock formations fundamental in the building of the Mount Lofty Ranges, two main divisions have long been recognised.

**THE FIRST STAGE OF THE ADELAIDE SERIES:
AS ILLUSTRATED AT MOUNT MAGNIFICENT**

By D. MAWSON

[Read 11 May 1939]

Of the rock formations fundamental in the building of the Mount Lofty Ranges, two main divisions have long been recognised.

ARCHAEAN ROCKS OF THE MOUNT LOFTY RANGES

The older formation is a complex of highly altered sediments and intrusive magmas. It has every appearance of great antiquity and has been referred to as Archaean. The distinguishing name Barossa Complex has been applied to it. A notable feature is the wide distribution through it of intrusions of dioritic and monzonitic composition. These are notably rich in titania. They apparently represent plutonic magmas which owe certain of their peculiarities to contamination as a result of some degree of assimilation of the injected beds. These invasions predated the deposition of the very thick series of overlying sediments which constitute the second main division of rocks to which reference has been made.

Rocks of this division have been described (1) from the neighbourhood of Williamstown, the Humbug Scrub area, near Houghton and the Torrens River Gorge, the neighbourhood of Aldgate, and in an elongated belt beginning about Section 251 of the Hundred of Kuitpo (2) and extending south and west to the Mount Compass Range, hence to the neighbourhood of Yankalilla, *via* Mount Cone. Rocks of this division re-appear beyond the Inman Valley in the neighbourhood of the Little Gorge south of Normanville.

The surface vegetation over a considerable area of this formation is remarkable for its poverty. Merely stunted scrub, mainly Xanthorrhoea, Hakea and Cosmophylla. The areas most marked in this respect are underlain by schists of a rather highly siliceous nature. Where invasions of an igneous nature occur the soil is rich and the best types of plant growth flourish. Thus, the margin of the intrusive masses is sometimes very sharply defined by the natural vegetation. The same applies to the delineation of the line of contact between the younger overlying series and the Barossa Complex, for forest growths flourish on the former.

PROTEROZOIC AND CAMBRIAN SEDIMENT

Above this Archaean Complex and separated from it by a violent unconformity lies the second, much younger group of rock formations, comprising thick masses of sediments. Intrusions of various kinds have penetrated these rocks also, but thus far there has been no satisfactory data available in the Mount Lofty Ranges area for determining the period of these intrusions.

Of the various large granite masses distributed along the eastern margin of the Mount Lofty Ranges and to the north of Mount Pleasant, some appear to be older Pre-Cambrian but others have intruded the second, younger division of rocks under review, resulting in the development from them of metamorphic schists and gneisses. Our knowledge in this regard is yet limited, but undoubtedly certain areas of metamorphic rocks on the eastern side of the Ranges are equivalents of the little-altered sediments of other areas.

The late Professor Howchin has been mainly responsible for our knowledge of the sediments of the Mount Lofty Ranges which overlie the Barossa Complex. Thus he has recorded (1) what he regarded as a continuous succession of some 13,000 feet of sediments between the basal beds at Aldgate and the sea at Marino. These are for all practical purposes of correlation devoid of fossils. Above them at Marino, Hallett's Cove and Sellick's Hill are later beds which Howchin again assumed to be a continuous succession and, since Cambrian fossils appear in the limestone of Sellick's Hill, the age of this upper section is fixed as Cambrian.

The underlying sediments of Howchin's succession between Aldgate and Marino have for some eighteen years past been generally accepted as Proterozoic, though Howchin (1) still indicated the possibility of a Lower-Cambrian age for them. With the extension of field observation in wider areas it was apparent, even as early as the year 1924, that in all probability this thick mass of sediments would be found eventually to include diverse formations separated by time breaks. Thus it was then suggested to Howchin by the late Sir Edgeworth David and the writer that a local name should be applied, non-committal as to age, and with the understanding that as knowledge of the formations progressed it should be dropped in favour of divisional names. Thus the term "Adelaide Series" was created as a temporary working tool.

Howchin's investigations of these beds were of a general nature and comparatively little detailed work of mapping and measurement was attempted. The faulted and broken nature of the beds in the neighbourhood of Adelaide renders a more complete investigation difficult and unattractive.

More recently Madigan (3), Hossfeld (4) and Segnit (5) have undertaken the mapping of areas in the Mount Lofty Ranges, and our knowledge of the Adelaide Series and related beds is slowly developing.

FIELD EXAMINATION OF THE MOUNT MAGNIFICENT AREA

It is the object of this present contribution to put on record details of the lower 5,700 feet of these beds as exposed in the neighbourhood of Mount Magnificent which lies about 24 miles by air line south-by-east of Adelaide. There the base of the Adelaide Series is well defined and the beds themselves are perhaps better exposed and have suffered less dislocation and metamorphism than anywhere else in the Mount Lofty Ranges. The area examined, shown in the accompanying map, has suffered faulting to a minimum degree. Consequently, the

measured and reduced thicknesses of the beds exposed are believed to be more accurate than any previous estimates of their true thicknesses.

The Mount Magnificent Range quartzite is a striking formation which constitutes an excellent datum for field mapping. Below it at no great distance

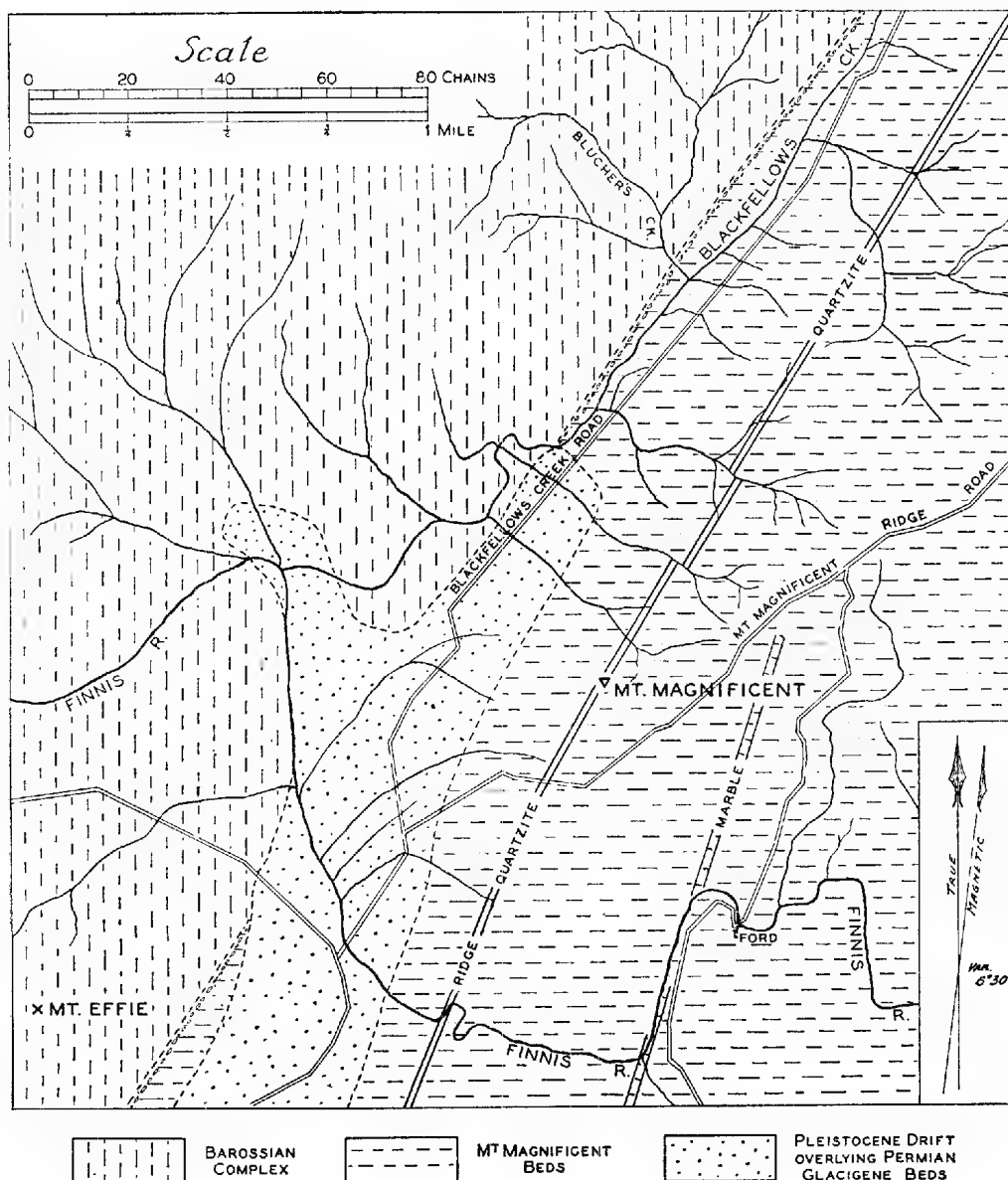


Fig. 1

lies the basal conglomerate, and above it is a striking belt of marble. This association we have now traced from near Ichunga on the north, southward through Mount Magnificent to Mount Jagged and Wood Cone and on to the Grey Spur

near the Inman Valley. Throughout this length the general direction of dip is towards the east-to-south quadrant.

In the accompanying account of the beds as occurring in the neighbourhood of the intersection of the Finnis River with the Mount Magnificent Range, true thicknesses only are quoted and the directions of strike and dip are "true," not "magnetic."

In the plan, fig. 1, only the broader geological features are shown. The junction of the Barossa Complex and the base of the Mount Magnificent Beds

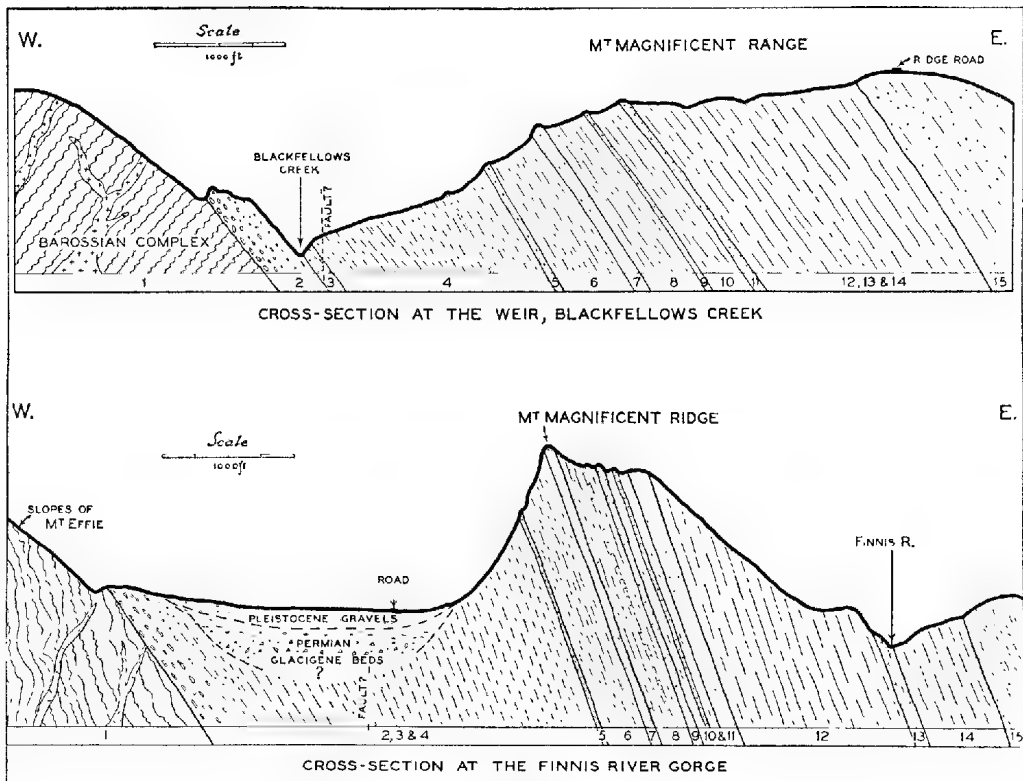


Fig. 2

is to be observed following down the course of Blackfellow's Creek until it disappears beneath a nearly horizontally disposed cover of Permian glacigene beds which are in turn for the most part veneered with Pleistocene pebble drift. Along the lower slopes of Mount Effie the basal conglomerate again appears for a short distance. No attempt is made to show the outcrop of the various components of the Mount Magnificent beds, except in the case of the belt of quartzite on which is the actual peak of the Mount.

In fig. 2 the section at the Finnis River gorge crosses an old valley-filling of Permian glacigene beds, veneered by Pleistocene drift. We have no information

as to the thickness of these beds at this point, and it is possible that the indication appearing on the plan is excessive in this regard. Actually there may be very little indeed of the glaciogene deposits at this spot though a considerable thickness is exposed near the junction of Blackfellow's Creek with the Finnis River. There is there a sandy tillite and a limited area of varved lacustrine beds.

DETAILS OF CROSS-SECTION OF THE MOUNT MAGNIFICENT BEDS

1. An ancient Pre-Cambrian complex underlying with marked unconformity the thick series of overlying sediments which make up the Mount Magnificent Range.

Some reference to this formation appears in a previous publication (2). In the area now under review it comprises rather highly siliceous schists and gneisses intruded by contaminated syenitic and dioritic magmas and occasional smaller-scale gabbroic and basaltic invasions, all of which are notably ilmenitic. A feature relating to this terrain is the abundance of ilmenite shed from it in the process of weathering and erosion.

2. Psephitic beds resting with marked unconformity upon Barossian gneisses and schists which are strikingly developed at the base of the Mount Magnificent succession. This division consists of coarse conglomerates of fluvial origin in which, under stress of dynamic pressure post-dating deposition, elongation of the boulders is apparent in the more stressed areas.

Where measured, near the Weir on Blackfellow's Creek, the total thickness of this section, which includes interbedded pebbly and sandy sediments, was found to be about 300 feet. A detailed statement of the true thickness of contributing strata measured from below upwards is as follows:

- 5 ft. of an arkosic arenaceous nature composed of quartz and felspar grit with some very small pebbles. Particles of ilmenite are abundant. In the weathered zone this is a comparatively soft rock, consequently the outcrop tends to be marked as a negative feature of the landscape.
- 10 ft. of a resistant coarse conglomerate, rich in boulders. Where measured the dip was 54° , strike $N.21^{\circ}E.$ (true). This strike represents the more general trend, but there are wavy local variations; the extreme extent of variation in the neighbourhood of the Weir was observed in the upper portion of division (par. 1) where there was recorded a dip of 57° and strike $N.30^{\circ}E.$ (true).
- 12 ft. of arkosic sandstone with abundant boulders distributed through it.
- 50 ft. of arkosic sandstone with only occasional boulders. Some bands are notably rich in ilmenite. One large embedded boulder measured 1 ft. by 9 in. by 9 in.
- 34 ft. of sandstone with occasional pebbles.
- 9 ft. of a richly boulder-bearing conglomerate. •

- 34 ft. of a richly ilmenitic sandstone: included therein are occasional bands of quite small pebbles.
- 12 ft. of sandstone with abundant laminae of very small pebbles which are mainly of milky vein-quartz.
- 3 ft. of a hard resistant pebble conglomerate constituted of small pebbles, none of which were observed to exceed 3 in. in length.
- 132 ft. of quartzite through which are scattered small pebbles and grit bands. Ilmenite grains are again a feature in some of the laminae.
- 300 ft. total thickness.

The aggregates represented in the above beds are normal water-worn and water-sorted materials. The pebbles are of all sizes up to an observed maximum of 15 inches in greatest dimension; they represent a variety of rock types, mainly quartzites and more or less metamorphosed phases of highly siliceous sediments; igneous types are present only to a minor degree. One of the quartzite pebbles collected is richly ilmenitic, another is a fragment of an ilmenite-bearing, pegmatitic quartz vein. Detrital ilmenite is present in notable amount both as chunks in the coarser beds and as sand in the finer-grained bands. Also, at several locations along the outcrop, the sandy phase of these beds has been observed to include laminae composed almost entirely of ilmenite grains.

On microscopic examination the matrix of the conglomerate is observed to be constituted of angular and subangular grains of quartz, a little acid plagioclase and microcline feldspar, and a notable amount of mica, both original detrital material and subsequently formed sericitic mica. The quartz grains exhibit strain shadows. Accessory minerals are ilmenite in great abundance, a little grey tourmaline, some minute zircons, and occasional fragments of sphene.

3. 100 feet of passage beds consisting at the base of 68 feet of fine-grained arenaceous beds, followed by 32 feet of arenaceous slates above.

4. 110 ft. of dark-grey slates, slightly phyllitic and faintly banded; where near the Weir the strike is to N. 35° E. In this latter locality the beds are intersected by a narrow, tourmaline-bearing, quartz reef. Further north, in the Memorial Park at the Kuitpo Industrial Colony, a small sulphidic lode has been exposed by prospectors. A mine shaft has been sunk on another slightly auriferous quartz stringer located near the Weir. There is some evidence that a strike-fault traverses this belt, but no indication was observed of any great displacement.

770 ft. of dark-grey slates. Towards the base there are intercalated in the slates several arenaceous bands, none of which exceed a foot in thickness. In some places near the upper limit, the slates become locally phyllitic.

2½ ft. of a hard light-coloured quartzite. This is well seen in the section from the Weir, but also has a counterpart in a dark siliceous band where cut by the Finnis River.

335 ft. of dark-grey slates which are for the most part flaggy. Where examined on the hill slopes above the Weir they were dipping 65° . These slates are well exposed on the Finnis River.

1,217 ft. is the aggregate true thickness of this division.

5. 16 feet of light-coloured, flinty quartzite, quite similar in petrological character to that of item No. 7 of the accompanying section, the quartzite which actually forms the ridge at Mount Magnificent itself.

6. 355 feet of dark-grey slates; where cut by the Finnis River the upper 150 feet of this division is harder and more siliceous, evidently re-crystallized after deposition.

7. 56 feet of a hard, flinty, white quartzite which, on account of its resistance to weathering, constitutes a notable topographical feature throughout the Range. Along a considerable portion of the outcrop the original sandy character of the rock has been obliterated and it has assumed a flinty nature which gives it a "fused" appearance. The rock of the outcrop at the very summit of Mount Magnificent is of this form; so also is the exposure in the bed of the Finnis River. Where cut by the section at the Weir the dip is 60° to $E.21^{\circ}S$. At the intersection with the Finnis the dip is steeper, about 70° .

A typical example of the "fused" type was found, when examined in microscope section, to be constituted of very fine, even-sized grains of quartz; also a minute quantity of very tiny flecks of white mica and still more rarely the minutest fragments of sphene or zircon are to be seen. The average diameter of the quartz grains in the slide is about .06 mm. The grains are allotriomorphic to interdigitating in their relation to each other and undulose extinction is discernible in many of them. A noticeable degree of alignment of the grains indicates incipient schistosity. There are some patches and tracts of coarser particles. This is evidently a quartzite that has undergone a considerable degree of crushing and recrystallization under dynamic pressure.

8. 300 feet of argillaceous beds, soft and slightly calcareous in part. At a point about half-a-mile south of the line of the Weir section, the calcareous slates of this division are notably phosphatic. There some of the stone has been quarried for rock phosphate but was found to be too low-grade to be of economic value. However, the phosphatic character of this horizon is so marked that surface soil along the outcrop is unusually rich, supporting superior vegetation. In regard to the latter, not the least feature is the large size and abundance of mushrooms appearing on this belt following autumn rains. Doubtless the explanation lies in the fact that the richness of the herbage on this belt has attracted sheep for very many years past; this concentration of sheep being the more direct cause of the rank mushroom growth. This calcareous phosphatic horizon has been traced from Black Swamp through Section 218 Nangkita northward to the Industrial Colony on Section 295 Kuitpo.

A more detailed examination of this division can be made where it is well exposed in the high cliffs along the Finnis River. There the true thickness is 257 feet, composed as follows: from below up, 54 feet of dark-coloured slate, 56 feet of highly siliceous slate, 55 feet of laminated, calcareous slates, and 92 feet of highly siliceous slaty rock. Recrystallization has gone so far that along most of the outcrop these slates have become incipient hornstones.

9. 26 feet of a hard blue-grey quartzite, where cut by the section from the Weir; at the intersection with the Finnis River it has very similar characters but has developed a thickness of 44 feet. In microscope slide the grain structure of this bed is very similar to that of item No. 7 except for some black opaque mineral substance sufficient to give the rock a dark appearance when viewed in bulk.

10. 220 feet of what are principally argillaceous beds. The lower division is slightly calcareous in part, while the upper portion is of harder and more resistant rock. The equivalent of this division where cut by the Finnis River amounts to 153 feet, near the middle of which is a 20-ft. belt of a more siliceous nature. The rocks of this division have suffered a considerable degree of recrystallization towards hornstone types. Further to the east (upwards in the series) metamorphic features are progressively more marked.

11. 40 feet of quartzite of a grey colour. Along much of the outcrop this horizon has suffered change to a highly siliceous granulitic hornstone.

Up to this stage the beds of this succession are, in the main, best exposed along the line of section at the Weir. Above item 11 there are better exposures in the section at the Finnis River gorge; accordingly, the measurements of the upper beds relate to the latter locality.

12. 1,160 feet of micaceous hornstone. This belt weathers more readily than the underlying quartzite. There are variations in composition throughout its great thickness. For instance, in the vicinity of the Finnis River intersection, the base of these beds is more highly siliceous for a thickness of about 100 feet. Also, the uppermost 275 feet is a denser form, of darker colour and slightly calcareous.

13. 100 feet of rather coarsely crystallized marble, in part white, elsewhere pink and mottled. This is well exposed in the Finnis River, which has cut its channel along it for 40 chains in that section of its course which turns north at 40 chains east of its crossing the Mount Magnificent quartzite.

This belt of marble is a notable and characteristic feature of the Mount Magnificent beds. It has been traced south into Section 1,769 of the Hundred of Nangkita. Northward it continues nearly to the top of Section 1,961 Kondoparinga, where it is then cut off by an E.-W. cross fault. It doubtless continues further north in Section 1,959 and beyond, but its further outcrop in that vicinity has not been observed.

This marble horizon varies in thickness at different points along the outcrop, the maximum observed thickness being 130 feet. At the Finnis River exposure it is inclined at 72° , dipping to E. 19° S. (true).

The following are partial analyses by W. B. Dallwitz of two samples collected from these beds on the Finnis River (Section 1965, Hundred of Kondoparinga).

				White Marble	Pink Marble
CaCO ₃	-	-	-	98.67	87.51
MgCO ₃	-	-	-	0.47	0.80
Fe ₂ O ₃	Al ₂ O ₃	-	-	0.11	0.60
Insoluble	-	-	-	0.36	10.69
				<hr/>	<hr/>
				99.61	99.60

14. 540 feet of finely granular micaceous hornstone, becoming more siliceous in its upper portions.

15. A hard, resistant, highly siliceous, granulitic hornstone. For the most part this rock is of a flaggy nature. It has been quarried to provide stone for the construction of a concrete ford across the Finnis River at its intersection therewith; at that point it dips 72° to E.20° S. (true).

Microscopically the rock is of a fine, granular nature, consisting predominantly of quartz; a considerable amount of feldspar (both orthoclase and acid plagioclase) and a little mica (chiefly light brown biotite) are present. This rock, and a considerable thickness of the beds to the east lying above it, appear originally to have been quartzite, but subsequently modified by metamorphosing agencies, the effects of which are more marked to the east, where within about 20 miles outcrops of granite occur.

GENERAL REMARKS

The country for several miles to the east of that dealt with in the present communication has been traversed along three lines of section, and a general knowledge obtained of the rocks there represented. As the presence of some important fault lines has been revealed and as the rocks become increasingly more metamorphosed in that direction, the interpretation of the rock succession above that dealt with in this paper is withheld until a more detailed study can be made of it.

However, sufficient is already known to state that the rock formations lying to the eastward are not merely faulted and folded repetitions of the beds already outlined herewith, but represent in addition a very considerable upward extension of the Mount Magnificent beds. Such rocks cover a large area, extending from the Meadows district eastward to Strathalbyn. Also, they are apparently rocks of this formation that extend south from the Mount Jagged - Grey Spur line to the south coast at Encounter Bay.

Though Howchin does not in his publications refer to the locality of Mount Magnificent, the beds here described are undoubtedly the equivalents of the basal members of his "Adelaide Series" succession. The Torrens River Gorge is the

area upon which he mainly worked when investigating the lowest division of the Adelaide Series. There, however, the presence of cross-faulting, developed to a considerable degree, renders the interpretation of the succession difficult and less reliable than in the less disturbed region of Mount Magnificent. The want of strict correspondence between the succession in the two areas is perhaps partly explained by the fact that deposition in shallow waters at points about 30 miles apart cannot be expected to be identical. It is specially to be remarked that whereas the marble horizons of the Torrens Gorge sections are highly magnesian, those met with in the Mount Magnificent section are notably deficient in magnesia.

Segnit, in his recent publication (5) upon an area lying about 20 miles to the north-north-east of Mount Magnificent, has shown that in that area the country is excessively dislocated by faults. This renders difficult the interpretation of the rock succession. Nevertheless, he distinguishes four distinct divisions of Pre-Cambrian sediments within the 25 square miles investigated. Thus Howchin's simple interpretations of these old sediments in the Mount Lofty Ranges is in process of abandonment in favour of greater complexity of the system.

The application of the term "Adelaide Series" to distinguish only the top-most division of what we have previously included under that comprehensive title is not at all helpful. Segnit might well have coined a new term or accepted that adopted by Hossfeld for the same division of sediments.

With regard to the beds which, in his area, Segnit refers to as the "Middle Pre-Cambrian," by their field relations it is indicated that these are the northward extension of the Mount Magnificent beds, and therefore represent the basal members of Howchin's Adelaide Series.

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 - 5 SEGUNIT, R. W. 1937 Geology of the Northern Part, Hundred of Macclesfield, Bull. 16, Geol. Surv. of S. Aust., Adelaide
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THE SIGNIFICANCE OF THE TOPOGRAPHY OF ANSTEY HILL, SOUTH AUSTRALIA

By CHARLES FENNER

Summary

Anstey Hill, a hill of incomplete circumdenudation, is composed of ancient altered sediments (pre-Cambrian quartzites, slates, etc.), and is 1,250 feet in height. It is one of the many hills that form the scarp front of the block-faulted Mount Lofty Ranges, and is thus to some extent tectonic in origin. The hill lies north-east of Adelaide, separated from the Torrens Gorge by Duncan Hill, and it commands an excellent view of the city, from which it is about nine miles distant.

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By CHARLES FENNER

[Read 11 May 1939]

PLATE III

I GENERAL DESCRIPTION

Anstey Hill, a hill of incomplete circumdenudation, is composed of ancient altered sediments (pre-Cambrian quartzites, slates, etc.), and is 1,250 feet in height. It is one of the many hills that form the scarp front of the block-faulted Mount Lofty Ranges, and is thus to some extent tectonic in origin. The hill lies north-east of Adelaide, separated from the Torrens Gorge by Duncan Hill, and it commands an excellent view of the city, from which it is about nine miles distant.

When one views the profile of Anstey Hill from a distance, as for instance looking northwards from the Gorge Road at Athelstone, two miles away, a peculiarity in its outline is apparent. The normal down-curving western front of the hill is broken by a projecting platform, almost level-topped, but with a slight slope seaward (westward.) (See pl. iii.)

When seen at closer range, this peculiar and arresting feature is revealed as a platform of ferruginous sands, fairly well consolidated for the top 12 to 20 feet (more in places), and merging into unconsolidated red and yellow sands beneath. The area of the flat top is, by rough calculation, about one and a half acres. Its height above sea level is 650 feet, but it rises towards the hill, and similar consolidated level-bedded sands extend, close against the face of the hill, some distance to the east, up to 700 feet above sea level, and also in a precipitous formation a few chains to the south.

In a series of "Topographic Maps of South Australia," published in 1926 by Major W. H. Edmunds, this peculiar relic of ferruginous sands is clearly marked in the north-east part of grid 7-E of his Millbrook map. Major Edmunds was evidently impressed by this flat-topped area, and referred to it as the "Gun Emplacement." It appears probable that, from the military point of view, this high flat area is a very attractive one, commanding in a remarkable way both the inner and outer harbours and the city of Adelaide. As this physiographic feature has no local name, we may for descriptive purposes adopt Major Edmunds' fanciful term, the "Gun Emplacement."

The early settlers found it necessary to have roads and tracks for transport and inter-communication between the settlements in the ranges and those on the lower plains and the Para Block. The Gorge of the Torrens River being too steep and rugged to permit of transport, the two chief points of attack for roads hereabouts were at Tea Tree Gully, a valley road, and at Anstey Hill, a ridge road (partly contour). The Tea Tree Gully roads are not shown in fig. 1, but the multitude of efforts to achieve an adequate surveyed road up Anstey Hill is

testified to by the complexity of the roads shown in fig. 1, a plan for which the writer is indebted to Mr. J. M. Maughan, of the Lands Department.

II HOWCHIN'S "DEAD RIVER" SYSTEMS

Professor Walter Howchin noted this interesting topographical feature, and incorporated it into his conception of the "dead rivers" of South Australia. In two articles the Professor developed his ideas of these hypothetical ancient features: "The Dead Rivers of South Australia. Part I. The Western Group," *Proc. Roy. Soc. S. Aust.*, 55, 1931, 113-135, and "The Dead Rivers of South Australia. Part II. The Eastern Group," *Proc. Roy. Soc. S. Aust.*, 57, 1933, 1-41.

The maps accompanying these papers show the supposed "dead rivers" as a series of long sub-parallel lines, extending as far north as Lake Torrens and Lake Frome, and as far south as Adelaide. The east-west limits of the dead rivers are restricted to an area extending from the centre of Spencer Gulf to the present valley of the Onkaparinga River. Within this limited width, less than 150 miles, no less than seven rivers are shown, and these are for the greater part of their courses somewhat parallel.

The writer has a very high regard for the work of Professor Howchin. Even in the two papers here mentioned the amount of detail and specification concerning the description and location of consolidated water-worn conglomerates bears witness to the careful records and extensive field work of the Professor, and constitutes a valuable fund of knowledge for future workers.

It is in the interpretation of the significance of these alluvial relics that difficulties arise. The writer believes these deposits to be of two distinct types of origin: (*a*) relics from the streams that meandered over the old pre-Miocene peneplain, and (*b*) re-distributed and re-consolidated (sometimes unconsolidated) remnants of the old pre-Miocene peneplain gravels, plus later alluvial detritus, deposited as "fault-apron" material, subsequent to the widespread faulting and differential uplift that dominates this area, and which is believed to have commenced in early post-Miocene times.

Thus it comes about that there is a rough association between the deposits of higher-level alluvials and the major fault lines of the Mount Lofty, Flinders Range, Yorke Peninsula, and Eyre Peninsula areas. These faults have been set out in some detail by the writer in his papers: "Adelaide, South Australia: A Study in Human Geography," *Proc. Roy. Soc. S. Aust.*, 51, 1927, and "The Major Structural and Physiographic Features of South Australia," *Proc. Roy. Soc. S. Aust.*, 54, 1930.

In these volumes the major faults of the area concerned are indicated. Subsequent enquiries by the writer, and publication by others, have extended and confirmed the series of roughly parallel, curving, north-south fault lines that so definitely determine the present-day topography of central southern South Australia.

The courses of the alleged dead rivers, as set out by Howchin, do not represent the normal courses of streams. The characteristic river pattern is dendritic in

form, however variously modified it may be by geological structures. Howchin's dead rivers, formed by linking up various deposits of siliceous, ferruginous, and unconsolidated alluvial materials, are a series of sub-parallel lines. If one linked up the separate deposits of re-sorted fault-apron alluvial materials that are found from place to place along the major fault lines, one would have a system of lines comparable with Howchin's dead rivers. The deposits themselves have, in this writer's opinion, been formed by streams, which cut back into the scarp faces, and flowed at right angles to the supposed directions of the hypothetical ancient streams.

The writer believes that Howchin's theory of the courses of the dead rivers, as set out in the papers quoted, is in the main an untenable interpretation of the facts. This aspect is dealt with in some detail because of its bearing upon the Anstey Hill deposits.

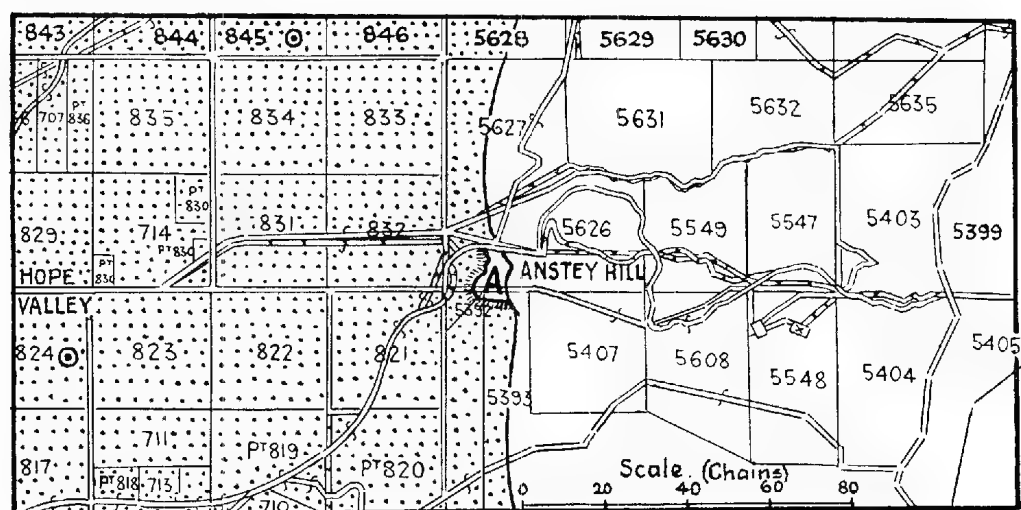


Fig. 1

Plan of the Anstey Hill area, showing roads, geology, etc.

III DETAILS OF THE GUN EMPLACEMENT, AND ITS SURROUNDINGS

Fig. 1 shows the plan of the Anstey Hill and Hope Valley area. The numbers of the blocks are given so that reference may be made to borings and other geological detail elsewhere available. The right-hand half of the plan represents the Mount Lofty Highlands, a well-dissected uplifted block of Pre-Cambrian quartzites, slates, etc. The western half (dotted in plan) consists of the lower Para Block which is here covered by sands and gravels, with clays and lignites at deeper levels. The north-south boundary between these two areas is approximately the position of the major western fault of the Mount Lofty Ranges in this area. In the centre of the plan, at A, is shown the platform of sediments that is the special subject of enquiry in this paper.

Fig. 2 represents the same area as fig. 1 on a similar scale, showing Anstey Hill, Hope Valley, and the alluvial platform at A. The contours are given with vertical intervals of 50 feet. These clearly indicate the dissected western scarp of

the Mount Lofty Ranges, which corresponds in this area with the boundary between the Pleistocene gravels and sands to the west, and the uplifted Pre-Cambrian sediments, etc., to the east. The maximum height of the range within this area is 1,350 feet, and it is likely that three separate differentially uplifted fault blocks are represented.

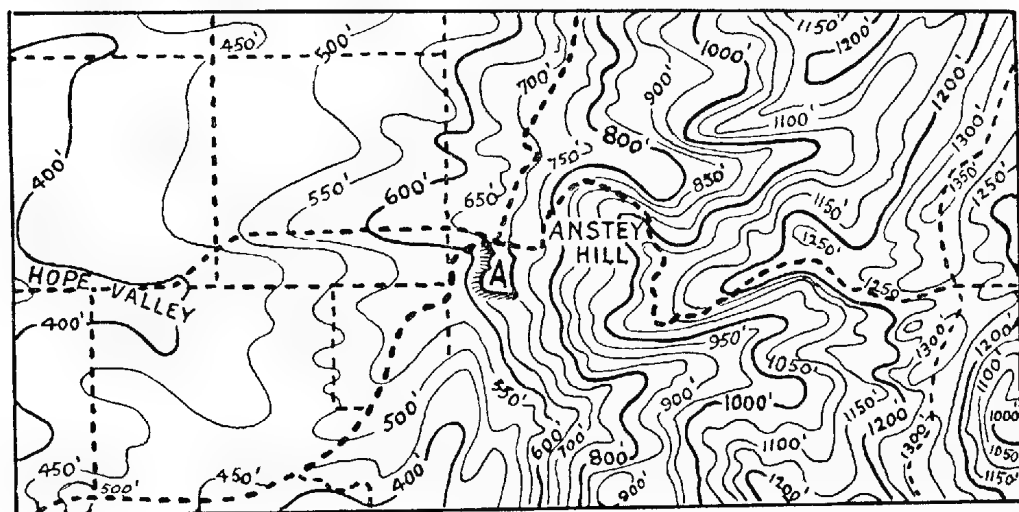


Fig. 2

Plan of the same areas as fig. 1, showing contours, V.I.50 feet. The broken lines represent present-day roads. A indicates the Gun Emplacement.

Fig. 3 is a section drawn from west to east through the middle part of figs. 1 and 2. This shows both relief and geology. The eastern highland block consists of Pre-Cambrian quartzites and slates, hard and resistant to erosion. The western lower block (the Para Block) is of more decomposed slates together

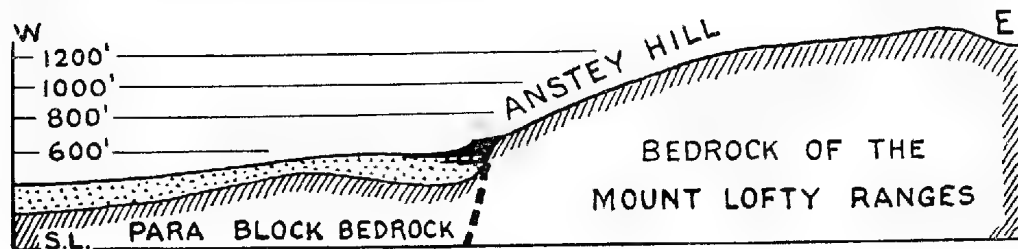


Fig. 3

East-west Section through the middle part of the area mapped in figs. 1 and 2, showing relief and structure. The Gun Emplacement beds are in black, the sands, etc., dotted.

with some quartzite, and within this area the block is covered, up to a depth of 200 feet in places, with sands, gravels, clays, lignites, and lignitic clays. The platform shown at A in figs. 1 and 2 is indicated in the middle of the section. The eastern and western blocks are divided here by a fault or faults.

IV THE ALLUVIAL DEPOSITS, THEIR ORIGIN AND AGE

Professor Howchin has traced with great care the sands and gravels hereabouts, and has shown them in fig. 2, p. 23, of his second paper on the Dead Rivers of South Australia (*loc. cit.*). Northward at Sampson Flat, where similar gravels also occur, there is definite evidence, both geological and physiographic, of the chief western fault of the Mount Lofty Ranges, running almost north-south, and separating the main range (here represented by Bald Hill) from the higher part of the Para Block.

Professor Howchin saw in the Hope Valley-Anstey Hill area three distinct terraces of his dead Barossa River, and there are indeed three distinct flat-topped areas of level ground within these alluvials. The first is at Highbury, 450 feet; the second a little farther towards Anstey Hill at 500 feet; and the third is the Gun Emplacement itself at 650 feet. Howchin, who counts these as three terraces on the left bank of a south-flowing river, makes no attempt to explain the whereabouts of the corresponding western terraces or the western slope of that river valley. When one considers the topographic section, east to west through the area, it is found impossible to imagine a set of conditions under which these three "terraces" could have been formed as river terraces of a stream flowing down from the north. The western side of the valley of the "dead Barossa River" not only does not exist today, but all the available evidence is against the possibility of it ever having existed.

There is little doubt that the whole of the gravels, sands, and clays in this area were laid down by heavily-burdened streams coming from the uplifted Mount Lofty Ranges and depositing their burden under fluvial, lacustrine, and fluvio-lacustrine conditions. The Gun Emplacement probably represents the highest part of one of these alluvial deltas. The material of this deposit becomes coarser towards the hill, indicating that direction as the source.

Several bores have been put down in this area, mostly in search of brown coal. The first of these, in Section 827, near the Hope Valley Reservoir, struck bedrock at a depth of 17 feet. The bore in Section 845 (see fig. 1) showed 60 feet of sand, gravel, and clay. Nine bores were put down by the Mines Department in Section 824 (see fig. 1) and passed through sands, pebbles, lignitic clays, lignites, and clays. The average depth of the alluvial deposits in Section 824 was about 200 feet. Ferruginous grits occur here and there on the surface at lower levels. These facts, with others gathered by the writer from field observations, are embodied in the Geological Section, fig. 3.

Age of the Beds—Apart from unidentifiable lignitic material, together with fragments of silicified wood and leaf fragments, there are no known fossils in these beds of sands and clays. Where the orange-coloured, even-textured, incoherent sands are revealed to their greatest thickness, reaching from the Torrens Valley near Springhead Farm, up to the foot of the scarp of the Gun Emplacement at Anstey Hill, there are numerous extensive openings where the sand is being exploited for building and other purposes. In these places its

character is shown to be quite unconsolidated—the sort of material which, in the phrase of Professor Douglas Johnson, would readily be washed away by erosion “like dirt off a board.”

That is to say, the continued existence of these beds today is evidence that they have not been exposed to erosive action for any considerable time. The harder iron-cemented beds of the Gun Emplacement itself readily weather to sands, and it would appear that the only difference between these upper beds and the underlying sands is a little greater coarseness and the presence of some ferruginous cement.

All these factors suggest that the beds must be relatively recent. Professor Howchin, who was inclined to be strongly influenced by the presence of lignitic material, classified the Hope Valley alluvials as “post Miocene.” The type of mottling in the iron-stained beds is reminiscent of the “mottled clays” that, in Victoria, are generally accepted as Pleistocene deposits.

The fault-front deposits of the Gun Emplacement are not to be confused with the much older iron-stained grits and sandstones that rest upon the old peneplain surface. The writer has investigated the “plateau ironstone grits” at One Tree Hill, at Blackwood, at Baker’s Gully, near Clarendon, and also on the residual uplifted peneplain above Tenafeate Creek.

At Baker’s Gully numerous specimens of woody stems and some beautifully preserved leaves were obtained, which were determined by Frederick Chapman as *Magnolia Broxtonii* (*vide* Trans. Roy Soc. S. Aust., 4, 171 and 179, also 61, 8; also “The Book of Fossils,” F. Chapman, 119).

There is little fossil evidence available in the Teatree Gully area. The bores in the western part of Section 824 (see fig. 1) revealed: (a) 20-30 feet of sandstone and surface materials, 30-40 feet of argillaceous sandstone, 70-80 feet of drift sand, and finally 50-70 feet of clays, lignites, and lignitic clays. “Some leaf fragments were obtained in the clay between the lignite beds at a depth of between 160 and 170 feet in No. 5 borehole. These were submitted to the National Museum in Melbourne, but were not sufficiently well-preserved for the age of the beds to be deduced. One leaf appeared to have been derived from a eucalypt.” (Mining Review, South Australia, No. 33, 1921, 27).

There is a clear distinction between the beds at and beneath the Gun Emplacement compared with the plateau grits of One Tree Hill, Baker’s Gully, and Tenafeate Creek localities. This may be demonstrated best from the physiographic point of view, but the lithological and palaeontological evidence, such as is available, also provides support for the distinction.

The plateau grits are uplifted, broken, and tilted by the faulting that affected the Miocene limestones. The major faulting was probably early Pliocene. The plateau grits, with their magnolia flora, were pre-fault deposits.

The materials of the Gun Emplacement beds, on the other hand, as well as the sands of Springhead Farm, Golden Grove, and Hope Valley are clearly post-fault in origin, loosely compacted or poorly cemented, with lignites and possibly

with eucalyptus leaves. The physiographic evidence in each case is incontrovertible. The Gun Emplacement beds are post-fault, therefore possibly Pliocene in the lowest beds, ranging up to late Pleistocene in the upper iron-stained cappings. The preservation of this platform against the erosive attacks of the Torrens and Dry Creek tributaries constitutes further evidence of a late Pleistocene to Recent Age.

V INTERPRETATION OF THE FACTS

The writer is impressed by the significance of the high level alluvials of Anstey Hill. At the same time it is admittedly difficult to determine the correct interpretation of the facts. Two possibilities are suggested, and each will be dealt with separately:

(a) The first hypothesis demands an acknowledgment of the existence, in recent geological times, of a vast and deep deposit of alluvial material over the Para Block and the Adelaide Plains, such as has never been considered as part of the geological history of this area.

(b) The second hypothesis requires the acceptance of a geologically Recent uplift of the western blocks of the Mount Lofty Ranges, together with the Para Block, carrying these alluvial beds to a height greater than that at which they were originally deposited.

Taking the first hypothesis (a), it is obvious that these alluvial beds, clearly fluvial or lacustrine, or both, cannot be accepted as a single and isolated occurrence. If they were formed at a height of 650 feet to 700 feet above sea level, about 500 feet higher than the site of Adelaide, then there must also have been deposited, at the same time, at or about the same height along the adjoining scarp face, similar alluvial deposits.

There is no possible barrier or rock-bank which could have caused the deposits to accumulate in this one place only, nor is there any special character in the streams here that would have given them greater powers of deposition. If such vast alluvial deposits existed up to 650-700 feet above sea level, along the face of the ranges in the Adelaide area, then their destruction (except for the Anstey Hill relic) has been complete and almost dramatic in character.

The second hypothesis (b) is that of recent uplift along the fault lines of the major blocks in the Adelaide area. The writer has already stressed the fact, *loc. cit.*, that the most westerly of the high blocks of the Mount Lofty and Flinders Ranges have undergone extensive uplift subsequent to the last movement of the more easterly blocks.

Evidence of this is found in almost every stream that crosses the blocks flowing towards the west. In the upper reaches of these streams, as in the Rivers Torrens and Onkaparinga, there are wide, mature valleys. As the streams cross the western blocks of the mountain range, the broad valleys are constricted to deep and narrow gorges. The geological evidence shows that this is not due to differential hardness of rocks. There is no geological reason for the change. The reason is structural, and is due to the more recent uplift of the western

blocks (not always the most westerly) of the ranges. This observation is equally true throughout some hundreds of miles along the western scarp of the South Australian cusp-shaped block-faulted highlands, and is evidenced in the following valleys known to the writer: Onkaparinga, Torrens, South Para, Light, Broughton, Willochra, Hookina, Brachina, and Parachilna.

The facts in the preceding paragraph are not adduced in favour of a Recent uplift, but of a Pleistocene movement. The probability of a late tendency to upward movement in the western blocks of our ranges is, however, of interest when we come to consider the possibility of Recent movements.

The scarp of the Para Block immediately west of the city of Adelaide, from the Newmarket Hotel to the Keswick Bridge, is a marked though low physiographic feature. It was one of the two ultimate factors that determined the site of the city itself.

This feature is an undoubted fault scarp. It is also a "dirt scarp." For over 20 years the writer has lost no opportunity of inspecting excavations in this area, such as wells, foundations for city buildings, and so on; one of these excavations was on West Terrace, on the very edge of the scarp. All these excavations showed the upper beds of the higher block to be muds, clays, sands, and gravels. It was in these materials that the scarp, west of Adelaide, was formed, and it is still sufficiently well preserved to be observable. It is an undoubted dirt scarp, the continued existence of which is clear evidence of faulting and uplift during Recent times.

Dr. R. Lockhart Jack has shown that fault scarps of Pleistocene to Recent age are to be found in the Counties of Jervois and York on north-eastern Eyre Peninsula. He informs me that there are undoubted fault scarps in "dirt" in that area. In the same region, and on the same faults, which are the western boundaries of the Spencer-Vincent Sunkland (just as those dealt with in this paper are the eastern boundaries of the same Sunkland), there are faults which truncate the Miocene and other Tertiary beds. Probably the dirt scarps mentioned by Dr. Jack are, in that area, later continuations of Middle Tertiary and Pleistocene movements, just as the Recent Adelaide uplifts must have been.

Dr. Jack's published account of this interesting series of western (Eyre Peninsula) faults is contained in Bulletin No. 3 of the Geological Survey of South Australia, entitled "The Geology of the County of Jervois and portions of the Counties of Buxton and York, etc." On page 9 of his paper Dr. Jack refers to the irregular fault, shown in his maps, which runs for nearly 50 miles from near Cowell to near Whyalla, and mentions the steepness of the scarp, ranging from 40 feet to 110 feet above the coastal plain, and refers to it as a "post Upper Tertiary" fault.

CONCLUSION

Good evidence exists for the occurrence of Recent movements of uplift on both the western and the eastern sides of the Spencer-Vincent Sunkland—the so-called Rift Valley of South Australia.



1 Looking north from Athelstone to Anstey Hill. In the central portion of the skyline is seen the flat surface of the Gun Emplacement.



2 Looking south from Anstey Hill road, at 650 feet, showing the beds of consolidated ferruginous sands that cap the Gun Emplacement.



3 Looking west from Anstey Hill, from above 700 feet, showing in the right foreground the level surface of the Gun Emplacement. The Para Block lies below and beyond.

Supporting evidence concerning the existence of dirt scarps, testifying to recent earth movements, involving the differential displacement of alluvial materials in this part of Australia is to be found in a paper by Dr. W. J. Harris (Proc. Roy. Soc. Vict., 51, 1939, 45). Dr. Harris writes to me (16/5/39): "The scarp from north of Echuca to Deniliquin is a dirt scarp, a grassy bank dropping decidedly from the higher level to the swampy, low-lying country to the east. In parts it is modified by erosion. At Mathoura the Gulpa has eroded it, and there is a clay and loam cliff."

It may be that the Gun Emplacement beds of Anstey Hill were originally deposited at their present height of 650-700 feet above sea level, 500 feet above the site of Adelaide, and in part covering that area; in which case they must have been part of a vast series of alluvial deltas for which we should seek further evidence along the scarp face of the Mount Lofty Ranges.

On the other hand, it may be that the Gun Emplacement beds were raised from a lower level to their present height by a differential uplift movement of a more Recent character than has hitherto been considered for the Adelaide Region. For this hypothesis also further evidence must be sought. In either case, it is desirable that we recognise the significance of the Anstey Hill alluvial deposits.

In the opinion of the writer both factors operated. There was probably a deeper and more widespread fan-delta alluviation of the Adelaide area, up to the scarp front, than has usually been considered. Also, there appear to have been late Pleistocene to Recent uplifts that affected these deposits.

The vast accumulations of alluvial material that covered portion of the Adelaide Plains have since been removed by erosion and have gone towards building up the great deposits of alluvial on the floor of the rift west of Adelaide (2,000 feet in the Croydon bore), and towards extending the Adelaide plains to the westward.

The Gun Emplacement itself is a unique relic. The writer is familiar with the whole of the fault-scarp front of the Mount Lofty Ranges, from Seacliff in the south to the lower part of the Tenafeate Creek Valley, thirty miles to the north. Apart from some minor occurrences between Anstey Hill and Teatree Gully (continuations of the Gun Emplacement beds), there are no remains of the same type at comparable heights. Should such beds be found, they would provide valuable additional evidence concerning the theories put forward in this paper.

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DESCRIPTION OF PLATES

The three selected views, from photographs by the author, show the Gun Emplacement, Anstey Hill, from various critical aspects: (1) looking north, (2) looking south, (3) looking west.

**ON MAMMALS FROM THE LAKE EYRE BASIN
PART IV THE MONODELPHIA**

By H.H. FINLAYSON

Summary

RATTUS VILLOSISSIMUS VILLOSISSIMUS Waite

This is the miaroo of the present-day Wonkonguroo, but it is said that in an earlier usage the word had a more general application to many, if not all kinds of rats.

ON MAMMALS FROM THE LAKE EYRE BASIN
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[Read 11 May 1939]

PLATES IV AND V

RATTUS VILLOSISSIMUS VILLOSISSIMUS Waite

This is the miaroo of the present-day Wonkonguroo, but it is said that in an earlier usage the word had a more general application to many, if not all kinds of rats.

First described by Gould, in 1854, as *Mus longipilis*, from a single specimen taken on Kennedy's expedition of 1847 to the Victoria River (the modern Barcoo), the type remained unique till 1894 when two more specimens were obtained by the Horn Expedition, which enabled Waite (2) to describe the skull. In 1905 Stalker took a series of it at Alexandra Station and Alroy Downs in the Northern Territory, which were briefly mentioned by Thomas (3). These and some references to its swarming (4) contain all that is known about it, and they leave *villosissimus* a very imperfectly known species.

Habits

It appears to be the only species of *Rattus* in the district and is here nearing the southern extremity of its range, which extends north and north-east over a large area of sub-arid Queensland and into the sub-tropical Gulf country of that State and the Northern Territory. It is of considerable general biological interest as constituting, *par excellence*, the migratory horde rat of arid Australia and the majority of the earlier references to swarms of *R. norvegicus* and *R. rattus* (and its synonyms) and of other large unidentified murids within the above area may be attributed with some confidence to it.

Ordinarily in the area (5) here dealt with it occurs very sparsely. In December, 1931, during my time in the district, its numbers were rapidly increasing, and towards the end of the month it was sufficiently numerous at night to be a nuisance in camps owing to its pillaging. This increase continued well into the winter of 1932 and died away again to normal sparseness by September of that year; since then there have been other increases, but on a much smaller scale. Some theoretical points arising out of these fluctuations will be discussed later.

Normally it is strictly fossorial and nocturnal and exceedingly obscure in its way of life. Even in times of increase, when the accommodation in burrows is quite inadequate and a proportion necessarily live upon the surface, it is very seldom seen in daylight, in summer at least. The burrows of the "resident"

population are almost always situated on the slope near the base of a sandhill and not upon claypans or gibber plains. The mouth of the hole is left open, and in several burrows which yielded rats on excavation the main drive extended 10 feet or more, obliquely towards the centre of the mound, reaching at the end a depth of 3 to 4 feet, below the sloping sand surface; at this level the sand was deliciously cool on days when the shade temperature reached 118° F. after several weeks of very hot weather. The actual length of the burrow is much greater than the surface measurement owing to the numerous undulations in a vertical plane, which are present. In some cases side passages leave the main drive, but they are blind and of no great extent. No nesting chambers nor young were found, and three sub-adults was the maximum taken from one hole.

When taken from the burrows and observed in a box cage their behaviour was fierce and pugnacious to a degree. The long coat was bristled erect, they squealed incessantly, the small dark eyes glared, and they rushed at material intruded into the cage and bit savagely and repeatedly. A behaviour pattern very different, or much more extreme, than what is to be observed under similar conditions with *greyi*, *lutreola* and *assimilis* in the south, and strikingly different from that of its associate *Pseudomys minnie*. In the twilight Mr. Reese has repeatedly seen miaroots in pursuit of *Mus musculus* and *Ps. minnie*, and the accounts of the blacks leave no doubt that while generally herbivorous, it becomes, when opportunity offers, an active and effective predator upon other murines, and possibly upon ground birds, too. Of seven stomachs which I examined on the Diamantina only one showed definite traces of animal matter, the others being packed with rather coarsely comminuted vegetable products, some of it apparently derived from the dark red seed capsules of a local *Hakca*. However, T. Wall, of Kennedy's Expedition of 1847, in notes transmitted to J. Gould, mentions that being intrigued as to how this species was subsisting in a district apparently destitute of vegetation and other animal life, he examined the stomachs of several and found them all to contain a fleshy mass. The assumed absence of other animal life may not have been so in fact, but Wall's emergent theory on the "cannibalism" of the rats is not improbable and certainly contributes towards the explanation of the rapid dispersal of swarms.

In spite of its strength and vigour, it is very intolerant of the summer sun. Two large males, taken uninjured from burrows, were placed in a cage and, through inadvertance, were left fully exposed to the sun at 11 a.m. on a very hot morning. When discovered, 20 minutes later, they were both dead; a curious instance of the lethal powers of sunlight and high temperatures upon a vertebrate.⁽¹⁾

On its reproduction there is little satisfactory information. All the males taken both in December, 1931, and the following winter had well-developed testes

⁽¹⁾ For comparable effects with ophidia see Nature, 27 January, 1934, 143; and Gregory, The Dead Heart of Australia, 133; and Spencer, Narrative of the Horn Expedition, 28

in prominent scrota. In six females examined, however, no embryos were found, nor were any nestlings taken nor independent young seen of less than about half growth. In the combined series of 26 specimens, on which the following account of characters is based, and which represents three gatherings, *viz.*, December, 1931, June, 1932, and April, 1934, there is a preponderance of males to females in the ratio of 2.2 to 1.

The rat has a powerful, persistent smell, which is still very evident in dried skins after seven years. When obtainable, it is eaten in large numbers by the local blacks. Its parasites have not been examined, though a *Laclaps* was noticed to occur.

External Characters

The following description is based upon living or freshly chloroformed animals in the field and is supplemented by reference to a series of 26 examples: 18 skins and skulls and 8 alcohol-preserved.

The rat is quite differently shaped from the familiar species *greyi*, *lutreola* and *assimilis* of the south, in that the body is long and tapering, and lacks the hunching of the hind quarters characteristic of these. The build is strong and active in young adults, but becomes excessively burly in old males corresponding to skull type "B" of the table of measurements. Although the contrary might be inferred from the skull, the head appears straighter in profile and less arched than in the above species; partly owing to the sleeker pelage of the crown and face. The eye is very small. The ear is also small; relatively thick in substance, without a fold line in the pinna, and is bluntly rounded without notching of the outline. The conch is pinkish within, but the upper parts of the pinna are pigmented moderately dark and are very sparsely haired. The mystacial vibrissae are only moderately developed; the lower anterior members white, the upper posterior black.

The manus is comparatively long but weak and slender in build. In a typical adult male of medium growth its length from the base of the carpal pads to the summit of the apical pads, 16 mm.; breadth across base of digits 2-5, 6 mm., and length of third digit, 8 mm. The palm bluish pink or white; interdigital pads small and unequal; the third larger than the other two and with a small satellite; carpals subequal.

Pes relatively large in proportion to the size of the rat, the ratio length of pes to length of head and body about 1:5.3; but decidedly narrow, the ratio breadth to length, about 1:5.0. The sole dark bluish, of the parallel-sided type, not tapering evenly to heel, but the heel suddenly constricted. Pads relatively low and narrow; second and third interdigitals subequal, pyriform, with their distal moieties much raised above the proximal, decidedly larger than first and fourth which are also subequal. Fourth usually with a small round satellite laterad to the main pad. The outer metatarsal very low, small and oval, about as

in *lutreola*. Inner metatarsal surprisingly long, 7 mm., narrow; almost as in *alexandrinus*. All pads smooth.

The tail is short, always less than the head and body; thick at the base and tapering rapidly. Mammae as given by Waite (2).

Gould's plate, the only illustration of the species extant, is good, but in general shape the figures are too *Pseudomys*-like and insufficiently rakish and the head too chubby and too small. The pelage is represented more erect than it normally is, and the tail is much too light in colour.

Pelage

As the existing descriptions are scanty and are based upon material apparently alcohol-preserved in both cases, the following brief re-description is supplied from freshly-killed animals and from skins made in the field without contact with a liquid preservative of any kind.

The outer coat is everywhere harsh on the dorsum and somewhat adpressed, except on the curve of the rump where the long guard hairs are somewhat upstanding. The villose character of the rat, however, is not much more marked than in some southern species, such as *lutreola* and *assimilis* where the hairs, if not as long, are more erect. The dorsal coat has a triple composition: (a) guard hairs upwards of 60 mm. in length, subcircular in section and jet black throughout their length or with a short white inconspicuous tip; (b) an intermediate series of about 20 mm. and more strongly flattened in section; these are slate at the base, a clear pale yellowish buff in the middle and with a short black tip; (c) an underfur 8-10 mm. long, of a medium slate grey, entirely obscured in a dorsal view. The resulting external colour is a pale grizzle of black and buff, cold and yellowish in tone, and this extends uniformly over the whole dorsum from muzzle to root of tail and with slight loss of the yellow element, on to the sides as well. In a few individuals small areas on the nape and rump immediately above the tail base are darker. The general appearance of the dorsum is similar to that of a pale *Isoodon obesulus*, and at a distance of 3-4 feet the colour corresponds roughly to Ridgway's "Isabella."

The ventral underfur is much paler slate with the flattened series white or ivory; the underfur shows through somewhat and the external colour of the ventrum is a greyish white tending to cream at the junction with the sides. The external aspect of the fore limb is coloured like the dorsum as far as the carpus, where it gives place at an angular termination to the pure white of the manus. In some examples the grizzling extends on to the metacarpus, but the digits and inner aspect of the limb are always white. On the hind limb the distribution of colour is analogous, except that the grizzling ends squarely at the tarsus and never invades the metatarsus. The tail is rather well clad on all surfaces with jet black hairs about 3 mm. long rather closely applied, but not obscuring the scutation which is as given by Waite. The jet black tail is conspicuously contrasted with the body colour.

Variation amongst skins which have had comparable treatment is very slight, both as regards age, sex and season. The coarseness of the grizzle and general tone of colour shows slight individual differences and the immature pelage is softer in texture than the adult, but the differences are of a minor kind. When comparison is made between the fresh field skins and those which have been made up at a later date from alcohol-preserved material, however, very decided differences are apparent. The latter have a decided warm brown suffusion, amounting in some cases to a rich ferruginous wash, especially marked on the flanks, and the ventrum varies from cream, through pale buff, to lemon yellow. That the differences between the two sets are really due to alcohol immersion is apparent from the fact that the effect is almost proportional to the duration of pickling; skins made up after a few weeks only in alcohol approximate to the fresh series, while those filled six years later show the most decided reddish tone and white labels with them are also stained. The colouring matter is possibly derived from the dark red ligneous stomach contents previously mentioned, but in addition to the changes from this cause there is a familiar fading of blacks to reddish browns. It is interesting to note also that the immersion in alcohol has two other effects: the grizzling appears to become coarser and more irregular, resulting in a mottled effect quite absent from fresh material, and the coat becomes fluffier and more erect.

Flesh dimensions are variable for adults within wide limits (see below) but part of the variation at least is due to the difficulty of applying strict tests for maturity, as explained in the treatment of the skull. The weights quoted are for rats taken in December, 1931, at Appamunna, but a series from Mulka in the following winter furnished several males of greatly superior bulk though not commensurate differences in other dimensions. The female is but slightly smaller than the male.

Skull and Dentition Eighteen examined. The very great apparent variability of the skull of this species has already been commented on by Thomas (3), and his remarks are partly borne out by the present series. Much of the inconstancy, however, is really due to a difficulty in applying satisfactory criteria of maturity. The closing of the parietal sutures, the development of the temporal and supraorbital ridges, the rugosity of the walls of the brain case and molar crown wear, are all initiated at an early stage in *villosissimus*. Of the 18 crania only one presents obvious evidence of immaturity in these particulars, and this is derived from a rat of less than one-half the bulk of the largest of the series; even so, its molars show appreciable wear. In the remainder of the series the 13 males shows a gradation through moderately ridged skulls having much the same dorsal appearance as adults of *R. rattus*, to excessively powerful, strongly ridged, rugose skulls somewhat recalling *norvegicus*. These latter (five in number) are also the largest in dimensions, and being fairly uniform in structure I would regard them as exemplifying the true cranial characters of *villosissimus* more accurately than the pseudo adult, *R. rattus*-like phase of intermediate size. The

largest skull is figured at pl. v, figs. D, E, F. The differences noted are fairly satisfactorily correlated with differences in flesh dimensions; the largest and most strongly ridged skulls belonging to the largest and most bulky rats, all taken in the winter of 1932. The outstanding features of the skull are its very powerful muscular sculpture, the very small lacrymals and large bullae in association with long narrow anterior palatal foramina, which may either reach the lingual cusp of the first lamina of M^1 , or fall short of it, but never, so far as this series shows, reach the middle of the tooth. The female skull is decidedly smaller and weaker than that of the male, even when comparison is made between individuals of approximately the same dimensions.

I find the similarity to *norvegicus* much less marked than stated by Waite (2). In addition to the distinctions given by him, it may be pointed out that in the largest skulls of *villosissimus* the muscular impressions are much more prominent than in the largest examples of *norvegicus*, and in all stages of the former the temporal ridges are strongly convergent posteriorly and never parallel nor divergent as in the brown rat.

Although, as shown in the table of dimensions, the limits of variation of the species can be contracted somewhat by segregating the individuals into what are, I believe, virtually age groups, there remains in each group a considerable variation both in dimensions and structure. It seems very probable that this is due to diverse origin. At a time of mass movements of rat populations such as were taking place when the series was gathered, a mixture of local strains, each possibly homogeneous in its own district, would inevitably result.

The series reviewed is apparently in satisfactory agreement with Gould's type, but the material taken by the Horn Expedition, which unfortunately is not accurately localized, but which certainly came from considerably west of the Lake Eyre Basin, exhibits some minor anomalies. The head and body length of the male measured by Waite is lower than the lowest value in my series (153 as against 164), though the molars would indicate an old animal, and in the skull the interorbital constriction is less developed and the molar rows are longer; the last may be due to differences in measurement.

It is to be noted that the type locality of *villosissimus villosissimus* has not been accurately laid down. There is nothing in Kennedy's journal upon Wall's activities as a collector, and if Wall's notes transmitted to Gould conveyed the information as to locality, Gould omitted to transcribe it. Thomas seems to have assumed that the type was collected at the Expedition's "furthest out," *i.e.*, on the Barcoo just below the 26° parallel and about 100 miles east of the location of the present series and in exactly similar country. It is quite possible, however, that it was collected in the second belt of subdesert country traversed by the party on its return, between the lower Warrego and Culgoa in north-west New South Wales, 400 miles south-west of the first locality.

Flesh Dimensions—The following figures give the range of dimensions in: (1) 12 males, all showing decided wear on M^1 and free from obvious immaturity in

other features; (2) 6 females in similar condition; (3) 4 males, showing the "intermediate" type of skull; (4) 5 males with strongly ridged skulls.

	(1)	(2)	(3)	(4)
Head and body - -	164-203	157-195	173-188	179-203
Tail - - - -	133-168	138-155	145-156	150-168
Pes - - - -	32-37	31-36	32-35	33-36
Ear length - -	19-23	19-21	19-22	21-23
Ear breadth - -	13-14 ⁽²⁾	11.5-12 ⁽²⁾	—	—
Rhinarium to eye -	19-22	19-21	19-21	20-22
Eye to ear - -	15-18	14-18	15-16	17-18
Weight (grammes) -	155-185 ⁽³⁾	110-175 ⁽³⁾	—	—

Skull Dimensions—The following figures give the range of values in: (1) 6 males (subadults?) of intermediate skull characters but decidedly worn molars; (2) 5 fully adult males with strongly ridged skulls and completely flattened molar crowns; (3) 4 females at a stage similar to (1).

	(1)	(2)	(3)
Greatest length - - -	39.3-40.7	41.2-43.9	37.6-39.6
Basal length - - -	35.6-37.8	38.6-40.3	34.0-35.2
Zygomatic breadth - -	19.4-20.7	20.8-22.1	18.6-19.0
Braincase breadth - -	15.0-15.8	15.7-16.5	14.9-15.2
Nasals, greatest length -	14.5-15.4	15.5-16.5	13.1-15.6
Nasals, greatest breadth -	4.0-4.8	4.2-4.7	3.4-4.5
Interorbital breadth - -	4.8-5.3	4.6-5.1	4.8-5.0
Palatal length - - -	21.3-23.0	22.6-23.5	20.5-22.0
Ant. palatal foramina -	8.0-8.6	8.4-9.2	7.6-8.0
Bulla: max. length - -	7.2-8.7	7.8-8.7	7.5-8.0
Upper molar row (crowns)	6.8-7.1	7.0-7.3	7.0-7.1

PSEUDOMYS (PSEUDOMYS) MINNIE Troughton

The pallyoora of the Wonkonguroo, and "river rat" of the older settlers.

Although there are references to it in the literature (4) under the latter name, the animal remained unrecognised as a species until 1930, when specimens collected by Mr. Reese were examined by myself. A portion of the same series was examined independently by Troughton, who published the above name for it (6). It was regarded by the latter as intermediate between *Ps. auritus* Thomas and *Ps. australis* Gray, but although it is perhaps originally derivative from such forms, it is now decidedly specialized to arid conditions, and in some respects may be regarded as a typical eremian product. While mindful of the specific identity of several Lake Eyre Basin mammals with coastal forms, the

⁽²⁾ Three only.

⁽³⁾ No weights are available for the largest males; a conservative estimate would be 250 grammes

impossibility of instituting adequate comparison with the rats named justifies, temporarily at any rate, the adoption of a full specific name. Similarly its relation to "*Mus fieldi*" Waite, though evidently close can be elucidated satisfactorily only by examination of further examples of the latter.

Its range is still to be worked out. In addition to its occurrence in the present area, Troughton has recorded a representative of it in the Longreach district of Queensland (7) and I have obtained it at several points west of the Lake Eyre Basin and as far south as Ooldea. It is excessively variable even within narrow territorial limits, and its migratory tendencies, even if less marked than those of *villosissimus*, make it probable that it will prove to be a plastic protean species over wide areas of the east and east central arid tracts.

Habits -In December, 1931, I found it very plentiful at Appamunna, Cooncherie and other points in the Goyder's Lagoon area. Unlike *villosissimus*, however, it had attained plague proportions almost a year before this and its population had already undergone several fluctuations. These culminated in the peak of May, 1932, following which there was a rapid decline to normal numbers again.

Its burrows are smaller and less elaborate than those of *villosissimus* and were always found upon clay flats or river banks and never in sandhills. They were shallow when on flats, not more than 6-8 inches deep, and frequently were in the vicinity of lignum bushes (*Muchlenbeckia cunninghamii*) and ran up from the mouth towards the roots of the same, but no second entrance or exit was noticed. All those excavated proved to be simple, without side passages and no nests nor nest chambers were found. A large proportion of the pallyooras, however were living under surface shelters of the flimsiest kind, one of the most frequently used being a shallow excavation under a disk of cattle dung. When riding about the country the blacks frequently noticed the conspicuous white tail imperfectly concealed in such a squat, and more than once dismounted and made an easy capture. In the main it is nocturnal, but was seen abroad more often than the other murids, chiefly, no doubt, through its being more easily disturbed in its trifling shelter. When driven from its holes in the day time, it proved to have little speed and was easily overtaken and caught by the blacks on foot. In disposition it is comparatively mild and gentle, and though it squeals and offers to bite when freshly taken from its burrows, it does so much less viciously than the miaroo and, with care, may be handled with impunity. When freshly taken from its holes in the day time and presumably newly awakened, the unusually large ear was seen to be folded or crumpled in an irregular way close against the head; when chloroformed in this condition, the ears slowly unfold and erect themselves completely and then show no trace of a crease line.

The diet, as deduced from the stomach contents and the accounts of the blacks, is purely vegetable. In all stomachs examined the mass of material is finely comminuted, pale and granular and evidently represents seeds and tender herbage; in a considerable number the granular constituent was mixed with a proportion of fine fluff, suggesting a vegetable pith.

The data available on reproduction indicate large fluctuations in activity, which, however, cannot be significantly correlated with any local ecological factors of which I have information. So far as females are concerned it relates to four distinct periods at three different localities, and may be summarized thus: (1) *June, 1931, Cordilla*: Of six females examined five were lactating and had uteri recently evacuated; one was pregnant with four full-term embryos (30 mm.); (2) *October, 1931, Appamunna*: Uterine condition not satisfactorily determined but reproduction evidently active, five growth stages being represented in the collected material, the smallest being helpless nestlings. (3) *December, 1931, Appamunna*: No embryos in two adult females examined, no nestlings found and the series of 18 taken includes none under half growth. (4) *June, 1932, Mulka*: Reproduction at a low ebb, but probably on the eve of a renewal; of 14 females examined, seven were not lactating and possessed non-pregnant quiescent uteri; the remainder were pregnant with early embryos, of which there were four in five individuals, five in one, and three in one.

The testes of adult males are variable in each of these batches; prominent and scrotal in some, retracted in others. The actual size of the testis, however, does not fluctuate as much as in some southern species.

The rat is free from the strong smell of *villosissimus*. It was heavily infested with a *Laelaps*, identified by H. Womersley (8) with a species occurring on *Pseudomys (Gyomys) apodemoides* 700 miles south.

External Characters—The original description is based upon a few individuals only, from one locality. As the animal is extremely variable, the following summary of external characters has been drawn up, based primarily upon living or fresh killed examples in the field, supplemented by a series of 78 specimens, of which 40 are alcohol-preserved, and 38 skins and skulls. The series is drawn from six distinct localities within the Basin, representing all the main types of habitat zones, in mid-summer and mid-winter, and in a wide range of developmental stages.

In life it is a beautiful little animal of variable but always delicate colouration, and notable among its allies for its very long ears and almost white, conspicuous tail, and a series of specializations somewhat reminiscent of *Notomys*. It is relatively long-limbed but, owing to the hunching of the hind quarters characteristic of the group, its general appearance is compact rather than slender. The head is of medium proportions, the ratio, length of skull: head and body averaging 1:3.8 in both sexes, and the muzzle rather long and heavy. The eye is conspicuously large and prominent, round and staring as in *Notomys*, and the diameter from canthus to canthus about 7 mm. Eyelashes, both above and below, are poorly developed; dark and contrasted with the somewhat lighter areas of the face. Mystacial vibrissae moderate, up to 35 mm. long; antero-inferior white, postero-superior black or black with white tips. Supraorbitals 27 mm., dark. Genals weak, 15 mm. The ear reaches 25 mm. in length (relatively much the longest recorded for the group), with a maximum width across the trough of the

pinna in its natural unfolded state, of 14 mm. Conch and lower parts of the pinna pale and naked; at the tips and towards the margins pigmented dark, but not strongly.

Manus very variable as to absolute size and the relative proportion of palmar pads. Its size is not correlated strictly with bodily size, and some of its stoutest manifestations are to be seen in small adult examples of the series. It is generally stouter in males than females. In the largest example its length from the base of the outer carpal pad to the third apical pad is 11 mm.; its greatest breadth 5 mm., and its longest digit 4 mm. All five pads are commonly crudely pyriform, and in the majority the carpals, which are subequal, are much larger than the three interdigitals, which are also subequal. Occasionally all five pads are subequal, and in a few the interdigitals are larger than the carpals. The outer interdigital and inner carpal are rarely duplicated or heeled.

The pes is equally variable. It is always long in comparison with the size of the rat; the ratio, length of pes: head and body about 1:4.5. The sole is narrow; its maximum breadth going into its length 5.8 times, and it is parallel-sided for a large part of its length and does not taper evenly to the heel, which is suddenly constricted.

In what might be regarded as an average condition, the second and third interdigital pads are pyriform and subequal, the fourth is much larger than the first and is broadened at the base and has a more or less distinct lowered heel separated from the main part of the pad. The first is similarly shaped but without the heel. The metatarsals are very reduced and rounded in shape, and the posterior of the two when present is about equidistant between toe tips and calcaneum. The degree of divergence from this condition may be thus summarized: (1) the first and fourth interdigitals may be subequal (46%); (2) the fourth may be simple and without a heel (41%), or it may rarely be distinctly duplicate with an entirely separate satellite postero-external to its base; (3) the first may be obscurely heeled (21%) and round, pyriform or variously elongate; (4) if the metatarsals are not subequal the posterior is larger and usually elongate instead of round. The anterior metatarsal is absent in about 2%; the posterior in about 13%; and both in 2%. These variations in foot character are strictly individual and occur in both sexes in all localities, and they are of practical moment as demonstrating the difficulty which may attend the definition of species by reference to such features.

The tail is short and weak; its length variable but on an average going into that of the head and body 1.1 times. In one immature example only is it slightly longer than the head and body. The scutation is everywhere obscured by its pelage, and the tip ends in a small naked, polished knob.

The mammae are limited to four abdomino-inguinals; no trace of pectorals being present in 21 females examined for this feature. When not functioning, the mammae, especially the anterior pair, are very completely retracted. The posterior pair are about 12 mm. in advance of the clitoris and are about 15 mm.

apart; the anterior pair about 11 mm. in advance of the posterior and about 22 mm. apart. In immature females until about half growth, the vulva is frequently occluded. In males the scrotal sacs are pigmented only upon the free nude posterior lobes.

The flesh dimensions are given below, where the measurements of five developmental stages from five separate litters are summarized in addition to the range for adults. In adults they show a wide range of variation, amounting in some items to 26%. The female, judged on the mean values for the whole series, is as large as the male.

Pelage—Colouration is exceedingly variable, but the variations may be reduced to four main groups. The following description is drawn up from a series of field-made skins from Appanunna and Cooncherie in December, 1931, which have had no contact with liquid preservatives and which represent the first of these groups. This type is here used as a standard from which to define the others.

Group 1—Coat relatively short, fine, soft, but not fluffy. Mid-dorsally the fur averages 13 mm. but has a sparse admixture of hairs reaching 18 mm. The shorter hairs are bicolor, the basal two-thirds approximating Ridgway's "Dark Plumbeous," the terminal third a bright clear buff varying from Ridgway's "Warm Buff" to "Cinnamon Buff." The longer hairs (scarcely coarse enough to be called guard hairs) have a thin plumbeous shaft and a jet black tip which is carried above the terminal buff zone and does not mix with it on the same levels. The general external colour from muzzle to tail base is thus a bright buff lightly pencilled with black. The belly fur is about 10 mm. long; its basal half a lead colour a little lighter than on the back, and the distal half snow white. The ventral and dorsal surfaces are separated by a lateral band of rich buff free from pencilling and handsomely contrasted both with the darker dorsum and white ventrum. The sides of the muzzle, for a distance of 6 mm. from the rhinarium, pale greyish without buff, the area sharply demarcated even in nestlings; the rest of the upper surface of the head like the back, and the throat like the belly. In the ear the inner aspects of the pinna are lightly haired with greyish-white, externally with greyish-brown, the external hairing concentrated on the margins, the anterior of which is the darker. Forelimb nearly pure buff externally in the proximal segment; lower segment, carpus and manus sharply defined pure white. Hindlimb externally much as the dorsum, buff on the femoral margin, internally white. Pes pure white above and with a conspicuous black grizzled patch investing the calcaneum and extending up the tendon 3-5 mm. Tail heavily furred with rather erect hairs, sparser towards the naked tip. Dorsally it is pencilled with a pale grizzle of black, white and buff, the density and extent of which are very variable; sometimes continued to the tip, sometimes confined to the basal one-fifth or less. All surfaces not grizzled are white, and the tail as a whole is conspicuously contrasted with the body. While the exact shade of colour varies, this colour phase is well marked and is probably a reaction to the claypan-flood plain type of

habitat, and though it is best represented in material from the two localities cited, it was obtained also at Ooroowillanie and Innamincka.

Group 2—This differs from Group 1 by the replacement of the yellow buff by pink hues ranging from Ridgway's "Salmon Buff" to "Vinaceous Cinnamon" and by the less prominent pencilling of the dorsum. It is best represented by a large series from Mulka in April, 1932, but occurs also in collections from Appamunna. The general type of colouration is paralleled by some strains of *Sminthopsis crassicaudata centralis*, and is possibly an adaptive reaction to the gibber plain-sandhill areas.

Group 3—Similar to Group 2 but with the pink tone replaced by browner colours, approximating Ridgway's "Tawny" or "Ochraceous Tawny." It is most plentifully represented in material from Cordillo but occurs also at Appamunna and (outside the Basin) at Arckaringa, 60 miles south-west of Oodnadatta.

Group 4—A pallid ashy phase. Two examples only from Cordillo.

In addition to this main colour variation, which, in the first three groups at any rate, is partly correlated with local conditions in the habitat, there is considerable individual variation in the batches from each locality. Though the three main types are quite distinct in their best examples, they intergrade perfectly through several variants in each group, and similar individuals are to be found in widely sundered places. The dark pencilling on the tail is remarkably variable in all localities, and so also is the calcaneal patch, though it is never absent.

Comparison of fresh skins of the three main types with material preserved in alcohol for varying periods has furnished some interesting data on the changes in colouration which must be looked for from this cause. The total effect, after seven to eight years, varies with conditions of storage, strength of alcohol, original fatness of the rat and stomach contents, but frequent effects appear to be: (1) a change of blacks to red-browns; (2) staining of white to varying intensities of yellow; (3) a change of pink and cinnamon tones to browns and yellow-browns.

Sexual differences in pelage are negligible, and so also are seasonal; age characters, however, are well marked. In furred nestlings of head and body length of 65 mm. the dorsum is much darker than in adults owing to the profusion and adpression of guard hairs, but below this the underfur is more richly coloured than in adults. At the 100 mm. stage the coat is erect and fluffy and nearly concolourous over the dorsum, the infantile guard hairs being entirely shed; the colour of the subterminal band is now as in adults. Later again with the progressive re-appearance of black "guard" hairs, from the rump to the head, the adult coat is attained. In fully adult examples the head is commonly pencilled like the back.

Skull Characters—The general characters of the skull are shown in pl. v, figs. G, H, I, of an aged male from Appamunna, belonging to the first pelage group. It is notable for the marked though variable concavity in the outline of the zygomatica, which generally reach their maximum width of arch near the posterior root. The subgeneric characters of the anterior margin of the zygomatic plate, the pterygoid

region and the dentition are shown without important variation by the whole series, but in many other respects, both metrical and non-metrical, the variation is wide, amounting in the former to 15% in some items. In the latter should be mentioned especially the differences in the zygomatic outline, in the shape of the interparietal in which the posterior margin may be either straight or strongly angular, and the palatal foramina which usually reach to the level of the mesial cusp of the first lamina of M^1 , but may fall short or exceed this. Sexual differences are slight, the female skull giving measurements as large or slightly larger than the male. The age changes are illustrated in the data for five growth stages taken from five litters, the flesh dimensions of which are also recorded.

The study of this rat affords a significant example of the uncertainties which may attend the taxonomic treatment of such forms when ample data is not available and is not used statistically. The variations, both in flesh dimensions and skull, can be partially localized and made to correspond in some particulars with each of the three main pelage types. Thus, for example, the bright buff phase from Appamunna in December, 1931, has on an average, a decidedly lighter skull with more concave zygomata than the pink type from Mulka in the winter of the following year, and the stunted adults of 1930 from Cordillo, have on an average larger manus and pes than either, in addition to a distinctive brown colouration. Comparison of the individuals from each group which exhibit maximum differences, would certainly, in the absence of additional knowledge, convey a strong impression of their subspecific or even specific difference. But in fact, all attempts to construe such differences in this way are frustrated by the presence of a large proportion of intermediate individuals in each locality, and by the frequent simultaneous occurrence of identical rat types at widely sundered places, though it may be on similar types of country. While average dimensions may vary from place to place, there is never a sharp break in any one dimension and the range of values overlaps in all localities tested, and forms a continuous series over the whole area. In addition to the variation in absolute dimensions as between individuals in the same area, there is the further complication of a lack of correlation of proportion in parts in the same individuals, such as can usually be readily traced and predicted in rats of the more stable coastal communities. Thus maxima and minima for skull dimensions, molar wear and foot, ear, and body length may be found indifferently in the same individual, thus complicating, incidentally, the application of maturity tests. In tabulating dimensions I have been guided chiefly, but not exclusively, by the extent of molar wear after a first rejection of all individuals showing the more obvious juvenile characters.

The heterogeneous nature of this species in the Lake Eyre Basin is, no doubt, to be assigned to similar causes to those which operate upon *R. villosissimus*, though in this case the results are much more marked. That is, in the first place, to a high inherent plasticity which enables the rats to colonize areas of river flats, flood plains, gibber plains, sandhills and claypans. Here life cycles are run

under different conditions of severity and detailed adaptation, which result in the moulding of definite strains or incipient races; and in the second place, to the uprooting and irregular commingling of these strains during times of mass migration.

Dimensions.—The following figures give, in columns 1-4 the dimensions of four individuals representing four growth stages, and in columns 5 and 6 the range in 25 "adult" females and 22 "adult" males of *Ps. minnic*, respectively.

<i>Flesh</i>	(1 ♂)	(2 ♂)	(3 ♂)	(4 ♀)	(5) ⁽⁴⁾	(6) ⁽⁵⁾
Head and body - -	53	66	73	98	106-138	103-140
Tail - - - -	27	43	57	85	87-116	88-113
Pes - - - -	15	18	23	26	26-29	26-30
Ear length - -	6.5	14	17	20.5	21-25	21-25
Rhinarium to eye -	8	—	—	—	15-17	14-17
Eye to ear - - -	7	—	—	—	9-12	9-12
Weight (grammes) -	—	—	—	—	58-75 ⁽⁶⁾	56-80 ⁽⁷⁾
<i>Skull</i>					⁽⁸⁾	⁽⁹⁾
Greatest length - -	—	23.1	—	—	30.3-33.2	30.7-33.1
Basal length - - -	—	19.5	—	—	27.1-29.9	26.3-28.8
Zygomatic breadth -	—	—	—	—	16.3-17.3	15.0-17.4
Braincase breadth -	—	13.7 ca.	—	—	13.9-14.6	13.9-15.1
Interorbital breadth -	—	4.5	—	—	3.8-4.4	3.8-4.4
Nasals, length - -	—	7.5	—	—	11.5-12.7	11.0-13.0
Nasals, breadth - -	—	3.0	—	—	3.2-3.4	3.0-3.8
Palatal length - -	—	13.8	—	—	16.3-18.0	16.0-18.0
Ant. palatal foramina -	—	4.9	—	—	7.2-8.2	7.2-8.1
Bulla - - - -	—	4.8	—	—	5.0-5.5	4.8-5.7
Upper molar series -	Not erupted				5.5-6.1	5.3-6.0

PSEUDOMYS RAWLINNAE (Troughton)

In the registers of the South Australian Museum, two specimens of this small dull-coloured rat are attributed to a collection from Appamunna. There is some doubt, however, as to whether they are properly localized. It is not represented in any series collected by myself in the Lake Eyre Basin, and, though its presence there is quite possible, its definite recording from this area must depend on future work.

PSEUDOMYS (LEGGADINA) cf. FORRESTI Thos. var.

A single example of a native mouse of the *Leggadina* group was included in a series of *Mus musculus* taken at Mulka in June, 1932. Material for a proper comparison with its allies is lacking, but though considerably smaller it agrees with Thomas's animal from Alexandra Station, in the large size, and laminate

⁽⁴⁾ 25 females
⁽⁵⁾ 17 males

⁽⁶⁾ 22 males

⁽⁷⁾ 4 females

⁽⁸⁾ 10 males

⁽⁹⁾ 6 females

character of the antero-internal cusp of the upper M^1 , in the crisp pelage and monocolour tail. From *messorius* Thomas, of which there are records from Lake Frome (geographically much nearer than Alexandra), it differs by its larger size, larger cusp and entirely white belly fur and tail. Its relation to *berneyi* and *waitei*, both evidently very close in essentials to *forresti*, can only be satisfactorily determined by examination of large series of all four. Pending this, the present animal is regarded as a race of *forresti* characterised by a pallid avellaneous colouration, shown by so many of the Lake Eyre Basin mammals, including *Sminthopsis larapinta*, which also occurs at Alexandra.

External Characters—Head broad with a comparatively blunt muzzle and thick upper lip. Mystacial vibrissae well developed and profuse; the longest 28 mm.; lower white; upper black; the longest of the set not white tipped.

Manus stout with well raised pads. Length, 8 mm.; breadth across base of digits, 2.5, 3 mm.; third digit, 3 mm. Inner carpal pad >, outer carpal >, second interdigital = first interdigital = third interdigital. Interdigitals rounded, simple, but much raised upon broad basal cushions; claws unusually slender and sharp-pointed. *Pes*: with the metatarsus parallel-sided, not tapering evenly to heel. Length, 17 mm. breadth at base of first digit, 3.5 mm.; calcaneum to inner metatarsal pad, 7.0 mm.; third digit, 4 mm.; pads well raised; second and third interdigitals pyriform, first rounded, fourth rounded and with a slight heel postero laterad, but neither the first nor fourth duplicated; metatarsals equal, small and round. Tail conspicuously shorter than head and body. Testes moderately developed, scrotal; scrotal epidermis not pigmented.

Pelage—Mid-dorsally, 7 mm. Texture crisp, with a considerable proportion of stout black guard hairs interspersed with the fur, but of the same length and not overtopping the latter to any extent. Basal two-thirds mid-dorsally medium plumbeous; terminal one-third a pale pinkish buff and the external colour a lightly grizzled avellaneous. Head greyer but grizzled like the back; sides less grizzled and decidedly pinker, especially at the junction with the white ventrum, which is sharp. Ventral fur pure white to base—rather coarse. Limbs lightly pencilled pink buff externally, white inside; manus and pes snow white. Ear inwardly, haired on posterior margin only, silvery white; outwardly well covered; silvery white except for a narrow band on anterior margin, where it is buff brown. Tail incomplete as to integument; proximal half well furred, scales obscured, greyish white on all surfaces, not bicolour.

The specimen is alcohol-preserved but is not stained and apparently not much faded.

Skull—Badly crushed, but the features intact agree with Thomas's description of *forresti* (9) and with Waite's figure of *Mus gouldii* (= *Ps. waitei*) in the Horn Expedition Reports, which is the only relevant illustration available, except that the anterior palatal foramina are longer than in the latter, and reach to the anterior quarter of M^1 . M^1 a very large tooth, its disproportion to M^2 and M^3 almost as in *Mus musculus*; its antero-internal cusp strongly developed, shaped as in *waitei*; incisors conspicuously orthodont.

Dimensions (in alcohol)—♂ Head, and body, 84; tail, 62; pes, 17; ear, 15.

Skull—Nasals, 7·6; interorbital width, 3·6; anterior palatal foramina, 5·5; M^{s1-3}, 4·3.

NOTOMYS AISTONI Brazenor

This is the oorarrie of the Wonkonguroo; it was first brought to my notice by Mr. Reese, who forwarded buff-coloured examples of it in 1929. On my visiting the area in 1931 it was obtained in numbers, and the first examples were then seen to represent merely a phase of a variation almost kaleidoscopic in range. Its satisfactory identification proved difficult owing to the inadequate description of *N. cervinus* of Gould; a difficulty which still persists. Meanwhile, the above name was published for another phase of the same animal, and pending further information on Gould's type, this is adopted here.

Habits—In December, 1931, it was plentiful at Appamunna and in the Goyder's Lagoon area generally, and had been so for a year or more. Its increase, however, had been gradual, and its presence was much less obvious at night than either *villosissimus* or *minnie* and it was never trapped in a camp. It is not included in the records of murid populations made by Mr. Reese, so that it is not possible to say how its numbers compared with those of other species, nor whether it participated in migratory movements within this area. Of migrations of allied species of *Notomys* elsewhere there are numerous accounts.

It colonizes all types of country, but its burrows were most frequently found on claypans and usually in the vicinity of lignum bushes, amongst the roots of which the exit hole of the burrow is frequently found. The burrows were very simple, seldom more than six feet long and comparatively shallow—9-12 inches below the clay surface. No side galleries were found, and though the entrance was sometimes marked by rows of pebbles, radiating warrens such as have been recorded for its congeners, were not observed. Some of the simplest burrows, possibly temporary, had only one opening, the numerous inmates then crowding into the blind end; five and seven were frequently taken by the blacks from these rather trap-like shelters. Oorarrie digging is a favourite sport with the black children who find and obtain them very easily, and large numbers are taken and eaten by them, as recorded by Sturt. Several were kept in captivity for a few days at Appamunna for observation, and Wood Jones' excellent description of the habits and mannerisms of the *N. cervinus* of Waite was found applicable in essentials to the oorarrie. Its gentleness was decidedly contrasted with the behaviour of several other species studied later in the western centre.

The diet consists largely of seeds, and the stomach contents of those examined in the Goyder's Lagoon area in December, 1931, consisted largely of pale finely granular material, not fibrous but copiously interspersed with dark fragments of seed case, probably derived from a *Calandrinia* sp. The material examined belongs to six collections taken in both summer and winter months during the years 1929-1934, at several points in the Goyder's Lagoon area of the Diamantina and at Mulka on the Barcoo. In all batches a large proportion of adults are

sexually inactive. Two pregnant females, taken in October, 1931, contain four early embryos in utero. Nestlings and one-third grown young were present in August, 1929, April, 1931, October, 1931, but were conspicuously absent in the collections made personally in December of the latter year. In the combined collections the sex ratio is 34 ♂ : 30 ♀.

External Characters—The following account of external characters is based upon large numbers of living or recently dead examples, supplemented by examination of the above-mentioned series of 64 individuals, of which 23 have been skins with skulls and the rest alcohol-preserved. For convenience in description, comparison is frequently made with the comparatively well-known and associated species *Notomys cervinus* of Waite (nec. Gould?), as it is represented at Mulka.

In the head there are a series of good characters which (in undistorted material) distinguish it from *cervinus* Waite. The head is broader and shorter, and conspicuously wider on the crown when seen from above. The upper lip is more heavily developed, deeper from above downwards and its free margin sloping back less acutely; the muzzle is shorter and wider and the rhinal appearance, generally, blunter and coarser. The mystacial vibrissae are enormously developed; the same length as in *cervinus* Waite (up to 65 mm.) but the bristles stouter. The antero-inferior bristles are white, the postero-superior black with white tips; the length of the white tip generally decreasing with age. The ear scarcely definably different, but its substance (before drying) a relatively pale slate colour in a large proportion of individuals and with the basal portion flesh pink and well contrasted with the upper pinna. The ear sometimes mottled pink and slate.

The presternal gland is present in all males and in a proportion of females as well (4 in 13). In males it undergoes marked changes in development, which are evidently related to the sexual cycle and may be summarized as follows: (1) In adult or subadult males in which the testes are undeveloped or retracted, the gland is also quiescent and is then represented by a presternal area of naked, punctate, yellow pigmented skin. In this condition its margins are indefinite and obscured by fur, and its size and shape vary widely; but it is always elongate longitudinally, is broader posteriorly, and in the largest example measures 4 x 8 mm. (2) The first sign of change is a general swelling of the chest area with a puffiness of the skin and increased punctation. (3) Next, the basal portion of the glandular area is elevated into a circular tablet 5-6 mm. in diameter, and standing 1 mm. or so above the general epidermal level. (4) The central portion of the raised area is next depressed forming a shallow pit completely surrounded by labial margins, which are sometimes heavier at the posterior border than elsewhere. The margins are haired sparsely but the basin remains nude in all examples examined, and is not covered by specialized hairs.

That the changes in the gland are periodic and reversible and are not due to age change alone, seems to follow from the presence of the gland in its maximum development in several young but sexually active males, and conversely in the

quiescent condition being found in several large sexually inactive males. In females the gland apparently never attains to the condition of a raised structure, but in four pregnant females it exists in the flat punctate state, quite as obviously as in any males.

The manus is variable in size, but the palmar structures are relatively constant. The interdigital pads are very much smaller than the carpals, and are subequal or the median rather larger; accessory folds or satellite pads are rare or absent; carpals subequal, or the inner larger. The pes is also relatively constant; stouter in the metatarsal portion than in *cervinus* of Waite, but the maximum width at the base of the digits about the same. All sole pads decidedly larger than in that species as represented in the same area; the third interdigital much larger than the second, and the fourth larger than the first. The hallucal pad is invariably present and with its fellow the fourth is rounded, while the second or third are pyriform or oval. No trace of metatarsal pads in any specimen. The sole is quite hairless but the undersides of the toes are lightly covered, but not sufficiently to obscure the apical pads, as in *cervinus* Waite.

Tail as in *cervinus* of Waite; its hairing and pigmentation variable (below): Mammae in a moderately prominent but not lactating set, with the posterior pair 11 mm. from clitoris; anterior 9 mm. from posterior; posterior 9 mm., and anterior 16 mm., apart. Scrotum pale, posterior lobes not pigmented. Dimensions as in *cervinus* of Waite for the head and body; the pes and ear averaging slightly longer, but the differences not significant. In all the external characters treated above the sexes are substantially identical.

Pelage and Colouration—The following characters are common to the whole series or represent variations which occur indifferently in the three main colour types. In texture the fur is fine, soft and erect, guard hairs absent. Coat generally dense but its length very variable; mid-dorsally from 10 to 14 mm. in examples collected at the same time and place. In unfaded material the basal colour mid-dorsally is "dark plumbeous" for rather more than half its length; this is succeeded by a rather shorter subterminal band of variable cinnamon or buff tone, and the extreme tip is black. The dorsal colour is fairly uniform antero-posteriorly, the head not differentiated markedly from the body in any of the many phases. The ears sparsely haired inside and out; inside the pinna with greyish white, outside variably in the different types—greyish white to decided brown. Tail always entirely white ventrally to within a few mm. of the tip, where the brush hairs are sometimes white sometimes black, but dorsally, varying for the proximal two-thirds like the ears. The terminal one-third is occupied by a brush of progressively lengthening hairs, blackish brown to jet black and to 12 mm. long. The external colour of the ventrum is always pure white, but basally is variable. In the majority of examples the lower belly is "pale plumbeous" basally and white on the chest and throat and inner forelimbs, but it is frequently dark over the whole ventrum and occasionally white over the whole ventrum—the latter condition more frequent in, but not confined to, subadults. On the sides, the external

colour is that of the subterminal band of the dorsum, variably pencilled as indicated below; the line of demarcation of lateral and ventral surfaces is sharp. The lips and lower part of face white. The limbs usually white internally and like the sides externally, but the forelimb sometimes white on all surfaces; hands and feet white.

The effects of alcohol preservation vary but in general are as outlined under *Ps. minnie*; a small proportion of individuals, however, have withstood eight years' immersion, with little change. Seasonal and sexual variation inappreciable; age variation much as with *Pseudomys minnie*. Individual variation in colouration extraordinarily great but following a definite plan, the main changes being brought about by the progressive operation of three factors, *viz.*, dilution of the colour of the subterminal band, increase in the length and profusion of the black pencilling and increased pigmentation of exposed epidermis. The range of colouration will best be presented by defining three main but overlapping groups.

Group 1—A handsome richly-coloured phase; the subterminal dorsal colour is about Ridgway's "Pinkish Cinnamon"⁽¹⁰⁾ to "Vinaceous Cinnamon"; the black pencilling of dorsum and sides is so slight that it is only perceptible on close examination and leaves the rich subterminal colour unchanged externally. The ears and proximal half of tail are pale haired—frequently white—and the epidermis of ears and tail are also pale.

Group 2—Subterminal colour progressively weakening through "Cinnamon Buff," "Pinkish Buff" to "Tilleue Buff," and the black pencilling increasing so as to further dull the external colour. The ears and tail base are variably darker, both as to hairing and substance. Intermediates of the northern flood plain series approximate to Ridgway's "Light Brownish Olive" in general dorsal colour; their analogues of the red country to "avellaneous," and the name "aistoni" is based upon the latter.

Group 3—The changes which convert type 1 into type 2 lead first in the direction of pallor, but later towards increasingly dark pelages, culminating in a strongly marked nigrescent phase, in which black is the chief element in the external colour. The ears and dorsum of tail are dusky as to epidermis and are haired dark blackish-brown.

Skull—Twenty-two examined: 10 males and 12 females, four or five only being obviously immature. As compared with *cervinus* Waite the skull is short and broad. The anterior zygomatic width is almost equal to the posterior and the anterior root juts out boldly from the orbital wall. The general zygomatic outline is almost parallel-sided (concave in the middle in some examples), and does not slope backwards markedly as in the first species. The muzzle and nasals are short but the width of both variable, and the latter usually making an abrupt transverse

⁽¹⁰⁾ I use Ridgway's term for this colour for the sake of uniformity, but it does not seem well chosen and tends rather to vitiate the distinction I have sought to indicate between the claypan and gibber plain types of colouration. The colour is a rich orange buff with little suggestion of pink as ordinarily understood.

line contact with the frontals of 2 mm. or more. The preorbital fossa as seen from above, shallow and with its exterior wall sloping inwards. Lacrymals moderate: transverse width up to 1.9 mm. Interorbital space very wide even in the oldest examples and expanding suddenly into a wide globular brain case. The anterior margin of the zygomatic plate is evenly and moderately concave; less deeply than in *cervinus* and the spur at the top is less developed. The anterior palatal foramina rather variable, but comparatively long, usually reaching to the lingual cusp of the first lamina of M^1 , and very broad at their posterior ends (maximum, 2.3 mm.). Mesopterygoid fossa also very wide (up to 2.4 mm.), generally parallel-sided but its exact shape variable. Both features much wider than in *cervinus* Waite; bullae smaller. Incisor index as determined by Thomas's method (10), ranging from 68° - 75° with a true mean of 70° .

The skulls of erythristic and atrate forms are quite indistinguishable. Sexual differences slight or nil. Age changes chiefly shown in the growth of the muzzle region; scarcely at all by muscular impressions.

Flesh Dimensions—The following figures give the range of dimensions of *Notomys aistoni* to the nearest 0.5 mm. at three growth stages, *viz.*: (1) Mean of two male nestlings; (2) mean of five subadult males; (3) range and true mean (in brackets) of 23 adult males; (4) range and true mean (in brackets) of 17 adult females.

	(1)	(2)	(3)	(4)
Head on body - - -	64	84	94-118 (104)	103-106 (105)
Tail - - - - -	72	119	125-155 (140)	125-157 (143)
Pes: length - - -	25	33	33-36.5 (35)	32.5-36 (34.5)
Pes: max. breadth - -	4.0	—	4.0-4.5 (4.0)	4.0-4.5 (4.0)
Manus: length ⁽¹¹⁾ - -	6.5	7	7-9 (7.5)	7-8 (7.5)
Manus: breadth ⁽¹²⁾ - -	3.0	3.5	3.5-4.5 (4.0)	3.5-4.0 (3.5)
Ear - - - - -	14.5	22.5	24-28 (25)	23-29 (26)
Weight (grammes) - -	—	—	32-39 (36) ⁽¹³⁾	35-52 (44) ⁽¹⁴⁾

Skull Dimensions—The following figures give the range in dimensions and true mean (in brackets) of: (1) 7 males, and (2) 10 females of *Notomys aistoni*. All free from obvious immaturity, but of varying molar wear:

Greatest length, 27.7-28.7 (28.1); 27.5-29.3 (28.2). Basal length, 22.4-24.6 (23.3); 22.5-25.1 (23.8). Posterior zygomatic breadth, 14.9-15.7 (15.3); 14.6-15.7 (15.2). Braincase breadth, 13.9-15.7 (15.1); 14.1-14.9 (14.5). Interorbital breadth, 5.8-6.2 (5.9); 5.4-6.0 (5.7). Nasals, length, 9.0-10.0 (9.4); 9.0-11.1 (9.7). Nasals, breadth, 2.7-3.1 (2.9); 2.8-3.1 (2.9). Palatal length, 13.6-14.5 (14.0); 13.6-15.4 (14.4). Anterior palatal foramina, 4.2-6.0 (5.4); 5.3-6.3 (5.8). Bulla, 4.8-5.6 (5.4); 5.2-5.8 (5.5). Upper molar series, 4.2-4.8 (4.5); 4.3-5.0 (4.7). Incisive angle, 68° - 75° (70°); 68° - 75° (70°).

⁽¹¹⁾ From base of outer carpal pad ⁽¹²⁾ At base of digits 2-5
⁽¹³⁾ 4 males ⁽¹⁴⁾ 7 females

The extremes of colour variation in this species are in remarkable contrast, but the wealth of data which has been reviewed leaves no doubt whatever of their specific identity. Not only are all essential structural characters both external and cranial, constant throughout the series, but the extremes are united by a long chain of intermediates which leaves no stage of the transition unrepresented. Nor is there any question of racial distinction between the phases, since the amplitude of the individual variation is the same in all of several localities tested, and representatives of the three main colour types were constantly taken together in one and the same burrow; they have little more claim to subspecific treatment than the polychromatic litters of *Dasyurus viverrinus*.

Nevertheless, though local variation is largely obscured by individual, there is the same tendency already noted in several other species in the area, for the development of adaptive colouration; orange and yellow buffs predominating on the great areas of claypan and flood plain on the Diamantina and pink and vinaceous buffs on the red sandhills and gibber plains elsewhere.

NOTOMYS CERVINUS of Waite et auct. (nec. Gould?)

Wilkie (?) of Wonkonguroo. The Appamunna blacks constantly upheld to Reese that in addition to the numerous colour varieties of the oorarrie, there was a second kind of kangaroo mouse, to which they gave the above name. They indicated further that whereas the oorarrie was ubiquitous, the wilkie was always found in sandhills. In the upper part of the Lake Eyre Basin it must be a comparatively rare animal (or was so at any rate from 1929-1932), vastly outnumbered by the other, and no specimen of it could be obtained while I was in the district in 1931, though parties of blacks were frequently searching for it. In 1932, however, two specimens were obtained at Puttaburra, west of Appamunna, and later an excellent series from Mulka.

As these last are nearly topotypical with the recently described material of Wood Jones from Killalpaninna, it will suffice to record some statistics of the series examined and emphasise the characters which separate it from the associated species.

The Mulka material belongs to two batches collected respectively in June, 1932, and April, 1934, and acquired from Mr. G. Aiston of that place. In the 1932 collection it was outnumbered by the oorarrie, 5 to 1, but in that of 1934 it outnumbered that species 25 to 1, though whether this is a safe criterion of their relative abundance in the field at the time is uncertain. Reproduction was quiescent in both lots; the mammae were retracted in all females examined save one, and no embryos were found in utero, though four nestlings at the H. and B. 70 mm. stage were included in the 1934 collection. Testes were all in the same condition; moderately developed with the posterior lobes of scrotum obvious, but much smaller than in oorarries taken at the same time and place. Males outnumbered females 21 to 7. Stomach contents without the *Calandrinia* element so conspicuous in the collections from the Diamantina.

External Characters—The head is differently shaped as indicated above, and the vibrissae are longer than given by Wood Jones, reaching 65 mm., and the larger members are as frequently white-tipped as dusky.

The gular gland is strongly developed in all specimens of both sexes except the nestlings, and even in these its site is indicated by an area of flaccid integument. Its presence is evidently constant throughout adult life and does not vary radically in macroscopical characters with any physiological cycle. The figures of Waite (2), Wood Jones (11) and Bourne (12), however, do not accurately represent the condition as it is shown by the present material, in which it takes the form of a nearly circular depressed area from 7-10 mm. in diameter, deepening caudad to form a sloping recess as much as 3 mm. below the surrounding level of the gular skin. The posterior and sometimes lateral margins are bounded by skin folds forming distinct but not fleshy labia, but there is no indication of the moulding with a central process as figured by Waite; anteriorly the floor is confluent with the interramal space. The entire area is sharply marked off from the rest of the gular surface by a dense covering of shining, somewhat adpressed specialized hairs which may be directed either centrad (as given by Bourne) or towards a median longitudinal line, in which case the area is bisected by a well-defined opposition ridge of hair. The feature only assumes the form of a shallow pocket when the animal is erect and the cranial and vertebral axes are at right angles; in the quadrepedal position, when the gular and ventral surfaces are in the same plane (as in fig. O, pl. iv), the glandular area is entirely open to view. There is sometimes a slight indication of a sternal gorget of adpressed hair, posterior to the gland area proper.

In the pes, the metatarsal portion is narrower on an average and all pads decidedly smaller than in *aistoni*; the second and third interdigitals vary in shape, are usually evenly pyriform but sometimes slightly constricted in the middle; the third but slightly larger than the second and sometimes subequal; first and fourth very small, and rounded; the fourth invariably present, but the first quite absent in one-third of those examined. The undersurface of the toes is strongly haired, the apical pads being partly obscured. The hallux is very reduced. The mammae in an apparently undistorted female are so disposed: posterior 8 mm. from clitoris; anterior 9 mm. from posterior; posterior 6 mm., anterior 11 mm., apart.

The average values and variation of flesh dimensions are much as in the associated species.

Pelage—When examined in the hand the pelage is seen to be decidedly different from that of the oorarrie; coarser, less erect, equally variable in length, but less profuse. The subterminal band is longer and the dark tips are sepia, not black, and do not contrast with the subterminal colour so as to give a pencilled effect. Ventrally the fur is entirely white. The ears and tail base are haired a very pale brown, never white nor black. Variation in the Mulka series (except for one anomaly) is at a minimum. The dorsal colour is a rich "orange cinnamon,"

deeper and more vinaceous than in any phase of the oorarrie. The anomaly represents the dark form of Waite; the dorsal colour ashy, about Ridgway's "Wood Brown" with scarcely a survival of rufous, but otherwise identical, even the whole ventrum white basally. The two specimens from the Diamantina differ from these not only in their yellower colouration (hardly distinguishable from some specimens of the oorarrie from the same locality) but have also a rather stouter foot, in which the hairing of the undersurface of the toes is less marked and a narrow line of hairs appears on the sole mesiad to the hallucal pad; in all essential characters, however, they agree with the main series.

Skull—Five skulls have been examined and compared with three of those described and figured by Waite in 1897, with which they are in close agreement. It should be noted that Waite's figure C3 of pl. vi is misleading in that it represents the bullae as far more globular and the anterior palatal foramina and mesopterygoid fossa wider than in the skull upon which it is based, or in any of those examined. In two of the Mulka examples, the upper M^1 shows a well-developed anterior accessory cingular cusp mesially situated below the anterior lamina.

Apart from the evidence provided by the skull, the subspecific relation of the Lake Eyre Basin *cervinus* to the examples described by Waite from more westerly districts (supposedly from Charlotte Waters or Alice Springs), is still uncertain. Practically all the material of the old collection of the South Australian Museum from these districts is labelled "*Ascopharynx cervinus*" (by Waite ?), but on examination proves to be referable to forms of *N. alexis* Thomas, and material for a proper comparison of external characters is lacking.

Flesh Dimensions—The following figures give the range and true mean for 16 ♂ and 6 ♀ of the Mulka series of *N. cervinus*, all apparently adult: Head and body, 91-115 (101); 98-108 (102). Tail, 135-153 (141); 127-146 (137). Pes. length, 33-35.5 (34); 33-35 (34). Pes. breadth, 4.0-4.5 (4.0) 4. Manus length, 7.8-5 (7.5); 7.7-5 (7.0). Manus. breadth, 3.5-4.5 (4.0); 3.5-4.0 (3.5). Ear, length, 23.5-26.5 (25); 24.5-27 (25.5).

Skull Dimensions—Range of values and true mean in three males and one female of the above series. Greatest length, 29.5-30.4 (30.0); 30.3. Basal length, 23.6-25.2 (24.4); 24.8. Posterior zygomatic breadth, 15.6-16.1 (15.8); 16.2. Braincase breadth, 14.7-15.0 (14.9); 15.3. Interorbital breadth, 5.1-5.7 (5.4); 5.7. Nasals, length, 10.1-10.9 (10.5); 10.5. Nasals, breadth, 2.8-3.3 (3.0); 2.8. Palatal length, 15.1-15.4 (15.3); 15.2. Anterior palatal foramina, 4.6-5.1 (4.5); 5.0. Bullae, 6.0-6.3 (6.1); 6.2. Upper molar series, 4.6-4.8 (4.7); 5.0. Incisive angle, 63°-68° (65°); 62°.⁽¹⁵⁾

The Nomenclature of the Kangaroo Mice of the Area

The use of *Ascopharynx* Waite to distinguish pouched from pouchless forms has little to recommend it, since a glandular area more or less recessed at some

⁽¹⁵⁾ Thomas's method

stage of its development is probably present in all species. *Podanomalus* to distinguish forms in which the gland is presternal rather than gular is open to a similar objection, since the shift in position is at most a matter of a few millimetres and in some forms glandular manifestations appear to involve both areas confluent, and may do so even in *cervinus*. The validity of the incisor character which it has been sought (13) to associate with the latter name is very doubtful. The clearance of *Notomys cervinus* from "*Podanomalus*" is but 2° (as quoted), and this is decidedly less than the average individual variation in the index within a species and is less also than the experimental error involved in its determination; there is now also the added confusion of a multiplicity of methods of determining the angle. For the present, therefore, pending more detailed knowledge of the whole group, it seems wiser to revert to Thomas's usage of *Notomys* for all the truly saltatory forms.

The question of the correct specific names for the two species of the Lake Eyre Basin is impossible of decision at present owing to the imperfect description of the type of *Notomys cervinus* Gould. In identifying an animal with a strongly marked gular pouch taken at Alice Springs or Charlotte Waters, with the animal taken by Sturt in the Grey Range area of north-west New South Wales, 500-600 miles east, Waite attributed a critical character to the type, for which there is no warrant in the original description of Gould of 1851, nor in the re-examination of Thomas in 1921. In all dried skins of *cervinus* Waite available to me the site of the throat gland is conspicuously marked by a shining disk of adpressed hairs abruptly contrasted with the rest of the throat fur and at once inviting curious attention. It is not likely to be disturbed by a knife in skinning, and that Thomas failed to record it in the type strongly suggests that it was not there.

Further, Brazenor's "*aistoni*" (devoid of a gular pouch) is founded upon a pale dull-coloured phase of an animal, the brighter buff forms of which are quite as much in harmony with those external characters of the type of *cervinus* Gould, which may be accepted with confidence as recorded, as is Waite's species with the gular pouch.

The cranial characters of Gould's animal are known only by some oblique comments by Thomas, in which they are contrasted with *N. mitchelli* (= *alexis*). These, particularly the enlarged brain case, the wide open palatal foramina, the wide mesopterygoid fossa, and the incisive index, all suggest "*aistoni*" more decidedly than *cervinus* of Waite. The matter will only be settled by a re-examination of the type, but should the doubt here expressed be confirmed and Sturt's animal prove to be an oorarrie, *aistoni* becomes a synonym of *cervinus* Gould, and Waite's animal will be innominate.

LEPORILLUS CONDITOR Gould var.?

Wopilkara of the Wonkonguroo. No trace of this interesting rat was found in the area personally worked over, and though it is well known to blacks and settlers and easily identified in popular accounts by its great unconcealed stick

nests, no evidence was obtained of its recent presence in any part of the Lake Eyre Basin. Thirty years ago, however, it was plentiful in certain restricted localities there, though always in the form of scattered and isolated colonies. Its disappearance here, as elsewhere, is probably due to inherent defects in its adaptations to the environment rather than to factors of pastoral settlement or persecution by the blacks.

In 1907 the South Australian Museum acquired four living examples from a locality in the immediate vicinity of the western shore of Lake Eyre. These were successfully maintained in captivity at the Museum for three years or more, breeding freely and rapidly producing a thriving colony of 16 individuals. They became very tame and confiding and early evinced the nest-building trait, approaching the taxidermist to take from his hand sticks of "old man saltbush" which were provided for the purpose. The building is a matter of the utmost deliberation and care, each stick being inserted and removed and re inserted several times until a satisfactory position is secured, when it is dragged into its permanent place from the inside of the mass. The latter operation frequently calls for great exertion from the rat and the total amount of work done in completing the fabric is enormous, and the fact goes far to explain the relative permanence in the bush of the seemingly flimsy structure. One such nest was preserved intact and now forms the locus of a mounted group.⁽¹⁶⁾

Fortunately, in addition to the mounted group (now very much faded), a series of eight examples were alcohol-preserved. These, on examination, prove to be so distinct from *conditor*, of Ooldea, and make so decided an approach to the insular *jonesi*, as to merit detailed description.

The differential characters presented may be thus summarized: the general linear dimensions and ear development are as in *conditor*, of Ooldea; the massive build and structure of manus and pes are those of *jonesi*; the colour markings are intermediate, and in the adult skull the nasal development exceeds both.

The series, comprising seven ♀ and one ♂, is uniform in all essentials and presents *external characters*, which may be summarized as follows: Form generally heavy, thick bodied, short limbed and powerful. Head: massive; profile moderately bowed. The hairy rhinarium, when undistorted, projecting well beyond and overhanging the nostrils. Mystacial vibrissae but moderately developed; not stout and the longest 60 mm.; mostly black at the base but a few of the longer white-tipped; supra orbitals 40 mm. Ears enormous; long, wide, and open; their length generously exceeding the rhinarium eye distance, in all except one in which it is equal to that value; their substance thick and leathery.

Manus strong and heavy; much stouter than in *conditor*, of Ooldea; length from base of outer carpal to apical pad of third digit up to 20 mm. Breadth at base of digits 2-5, 8 mm.; length of third digit to 9.5 mm. The palmar pads show no great disproportion in size. Outer carpal > third interdigital > second inter-

(16) For these details I am indebted to Mr. J. Rau, formerly taxidermist at the Museum, to whose care the success of the experiment was largely due.

digital = first interdigital = inner carpal. The pads crudely pyriform or sub-triangular; the third interdigital decidedly more triangular than the rest, and with its base proximad and a small satellite laterad; outer carpal with a heel laterad.

Pes very strong and stout; length to 46 mm.; breadth transversely across the sole at the base of the first digit to 10 mm.; breadth opposite the distal end of the inner metatarsal pad to 8.5 mm. Calcaneum to base of inner metatarsal 17 mm.; third digit, to 10.5 mm. The heel is strongly constricted; more so upon the inner margin, where there is an invasion of hair on to the sole; on the outer margin 5 mm. from the heel, there is an elongate calloused pad, but without relief. Basal interdigital pads reniform, with distinct heels or accessory pads in the concavity laterad. The inner metatarsal narrow and elongate, semisigmoid or almost straight; to 6 mm. long, but the posterior extension sometimes obscure; fourth interdigital > second = third > first > outer metatarsal.

Tail very thick basally and strong; scutation obscured by dense hairing in all but two abraded specimens; its length less than the head and body in five specimens, slightly greater in three. Mammæ: retracted and quiescent in all; their site very posterior and set close together for so large a form; posterior 10 mm. from base of clitoris; anterior 12 mm. from posterior; posterior 12 mm. apart, anterior 25 mm. apart.

Pelagee: Too faded for an accurate account but evidently originally quite close to *jonesi*, though perhaps more grizzled. Mid-dorsally to 17 mm. but variable in the series. Ear fairly well furred, medium light brown inside over upper pinna, darker brown outside especially on upper posterior margin. Tail strongly haired in most examples, with a slight lengthening distally but no brush; strongly bicolor, dark black-brown above (originally near black ?) and honey-coloured beneath. Markings of hands and feet intermediate between *conditor*, of *Ooldea*, and *jonesi*, but nearer the latter. On the dorsum of manus a dark band extends from the carpus to base of digits four and five, spreads over the whole of the digits and then half-way down the inner margin; the interspaces are almost white and a longitudinal four-banded effect is produced the sequence from the inner margin being dark white, dark white. The colouring of pes similar to *jonesi*; a much greater infiltration of dark hair than in *conditor*; the dark areas originally were evidently less intense than in the former however, and less strongly contrasted with the white; the dark area on the external aspect of the heel is less than in *jonesi* and does not connect with that of the digits.

Variation very slight; one subadult example has a much shorter ear than the rest (31 mm.) and approaches *jonesi* in the colour of the manus, but is evidently a variant only.

A Laclaps occurs sparsely.

Skull—Five examined, two only fully adult. In most characters both metrical and non metrical these two show a blend of *conditor* and *jonesi* as recorded. The nasals, however, are longer than in either (19.1 as against 17.5) and are also wider (6.2 as against 5.5), the maximum width being attained by a

sudden bulbous expansion within 5 mm. of their tips; a shape familiar in several *Rattus* but not figured for *Leporillus*; in the younger skulls it is less developed. The interparietal is not sharply angulated posteriorly in any of the five. The zygomatic breadth is greatest anteriorly in one, posteriorly in the other. The anterior margin of zygomatic plate straight but nearly vertical. Anterior palatal foramina large and open; in adults reaching to the first lamina of M^1 . A distinct median subincisive foramen communicating freely with the nares, is present in three examples and an os bregmaticum in two. Incisor enamel very pale.

Dimensions—The following is the range and true mean in seven females and one male, all free from obvious immaturity: Head and body, 161-195 (185). Tail, 160-200 (177). Ear,⁽¹⁷⁾ 36-41 (38). Pes, length, 43-46 (45). Pes, breadth,⁽¹⁸⁾ 8.0-8.5 (8.5). Manus length, 17.5-20 (18.5). Manus, breadth, 7.5-9 (8).

Skull Dimensions—The following is the range in two fully adult females with much worn molars: Greatest length, 47.3-47.3. Basal length, 42.5-43.4. Zygomatic breadth (max.), 23.2-23.5. Nasals, length, 19.1-19.0. Nasals, breadth, 5.5-6.2. Interorbital constriction, 5.0-5.5. Palatal length, 25.6-25.6. Anterior palatal foramina, 9.9 x 3.8-10.0 x 3.5. Braincase breadth, 19.4-19.6. Bullae, 8.3-9.5. Upper molar series, 9.3-10.3.

While it is unfortunate that authentically wild caught specimens have not been available, the history of the series in captivity is too short to vitiate the very real distinctions which it presents. No record was kept of the fate of the four progenitors of the colony, and it is quite possible that some of them are actually included in the above examination; the very aged condition of two females (see pl. v, figs. A, B, C) suggests that such was indeed the case.

Uncertainty as to the detailed characters of the type of *conditor* from western New South Wales renders it inexpedient at present to apply another name to the present form. Whatever its status may be, the animal is of systematic interest as tending to bridge the gap between the mainland *conditor* and the insular *jonesi*, though its place of origin is actually more remote from Franklin Island than is Ooldea, whence most examples of *conditor* have come. That all four are related subspecifically seems very probable. Many of the distinctions which have been drawn between *conditor* and *jonesi* are hardly of specific rank and would doubtfully stand the test of submission to long series; and in several points, as for example the condition of the interparietal and inner metatarsal pad, there is a conflict in the statements of the two latest reviewers (14) (15).

HYDROMYS CHRYSOGASTER Geoffroy

Known to the Wonkonguroo as tinna appa, this species occurs sparsely not only in the main channels of the Diamantina and Barcoo but after floods in many outlying lagoons as well. When these dry out the tinna appa makes back to the

⁽¹⁷⁾ Excepting the above anomaly in which it is 31 mm.

⁽¹⁸⁾ Opposite the distal end of the inner metatarsal pad.

semipermanent pools of the two rivers, and in doing so performs some very remarkable journeys. The travelling, of course, is done at night only and distances are seldom more than a few miles, but to anyone knowing the creature only in its typical habitat of shady pools in the green coastal lands, the bare claypans and gibber flats which must be crossed would appear as an insuperable barrier to a form with such modified limbs, and, indeed, in many cases must call for great resource and enterprise.

A single example was obtained in the Barcoo near Innamincka; it is a very large female and can be closely matched by some of the more conspicuously grizzled examples of *H. chrysogaster* "*fulvolaratus*" from the southern districts of South Australia, though, as I have pointed out (16), this form is so exceedingly variable as to make its definition as a race very difficult.

Flesh Dimensions—Head and body, 355. Tail, 285. White of tail, 120. Pes, 68. Ear, 20 x 11.5. Rhinarium to eye, 32. Eye to ear, 27. Weight, 500 grammes.

Skull Dimensions—Greatest length, 61.8. Basal length, 58.0. Zygomatic breadth, 32.0. Braincase breadth, 22.1. Nasals, 21.3 x 5.8. Intertemporal width, 6.9. Palatal length, 35.7. Anterior palatal foramina, 6.7. Bullae, 7.2 ca. Upper molar series, 9.5.

OTHER INDIGENOUS MONODELPHIA

The dingo (*Canis familiaris dingo*) is widespread in the area and local increases of it were reported several times during plagues of murids. In December, 1931, it was not sighted and its tracks were infrequent. In spite of the presence of stock its numbers seem to be much less here than in the unstocked districts of the western centre. The Wonkonguroo call it mudla, and the Dieri, kinturra.

Bats were not systematically sought, but occur very sparsely. A single specimen, taken at Pandi Pandi on the Diamantina proved to be *Nyctophilus geoffroyi pallescens* Thomas. The Wonkonguroo name for bats in general is pinchi pinchi narra.

INTRODUCED MONODELPHIA

Mus musculus Linne (vars.)

The "house" mouse is thoroughly established in almost all parts of the area, and, as far as can be ascertained, lives the life of the indigenous murids, burrowing in times of normal populations and sheltering precariously under surface litter when swarming. It is subject to the same astonishing fluctuations in numbers as the native rats. In 1930, in the Goyder's Lagoon area, after a long period of steady increase its populations suddenly broke away in swarms of magnitude comparable with those of the historic 1916 plague in the wheat belts. In December, 1931, I found it comparatively scarce, but it could still be trapped in some numbers at the homestead at Appamunna and was occasionally taken in the field.

The Wonkonguroo call it punta punta, and the fact that they have a distinguishing name for it while the rabbit and fox go unnamed, suggests that *musculus* has had a longer tenure of their country than these two introductions. The variability of rural mice in Australia has been commented on by several authors and Wood Jones (17) has referred to a red-brown "desert form" from Miller's Creek in South Australia, though a suspicion of immaturity attaches to the figures and skull characters as quoted by him. A larger version of this form is also the dominant variety in the Lake Eyre Basin, and though urban types also occur there, the red-brown, white bellied form with strongly bicolour tail, is never taken, as far as I can ascertain, in the towns or settled areas of the south. The possibility that the central type may be a derivative from Asia long pre-dating European settlement in Australia cannot be neglected, and is not to be discounted by the negative evidence of an absence of collecting records.

As proper comparison with named races has not been feasible, I withhold a subspecific name pending further work, but the following brief account, based on a fairly uniform series of 29 individuals from Mulka in June, 1932, will serve to define the Lake Eyre Basin race or strain.

The series comprises 14 females and 15 males. The testes were developed and scrotal in all males, even in those of hali growth, but none of the females examined were lactating or pregnant. *Laelaps* quite absent.

External Characters—Mystical vibrissae rather weak, up to 26 mm.; the lower shorter bristles white, the rest dark brown, only occasionally white-tipped. Supraorbitals to 15 mm. Ear small, very bluntly rounded at tip.

Manus: length, to 6.5; breadth at base of digits, 2.5, 2.8 mm. Pads rounded or irregular. Carpal pads subequal or the outer larger; both slightly bigger than the three interdigitals, which are subequal. The basal interdigitals sometimes duplicated.

Pes: length to 19 mm. Breadth at base of first digit, 3 mm. Calcaneum to base of inner metatarsal pad, 7 mm. Pads small, rounded and little differentiated in size; second interdigital > third = fourth = first = inner metatarsal = or > outer metatarsal. The basal interdigitals both completely duplicated; their satellites quite separate, posterolaterad, and almost as large as the main pads.

Tail comparatively thinly haired and scales everywhere obvious. Scrotum pigmented dark. Postero-abdominal mammae 7 mm. from clitoris, anterior 9 mm. from posterior. Posterior 7, anterior 14 mm. apart.

Pelage—Mid-dorsally 7 mm.; sleek, soft, and practically without guard hairs. Basally very dark plumbeous for two-thirds its length, then reddish-brown, slightly darker terminally, but with little pencilled effect. General external colour of back from "Mars Brown" to "Mummy Brown," lighter on sides and head. Ventrums pure white to "Pinkish Cinnamon" externally; basally pale plumbeous or white. Ears fairly well haired, medium brown inside, darker brown outside,

blackish on upper anterior margin. Hands and feet pure white or greyish white. Tail decidedly bicolour; black-brown above, white on sides and below.

Dimensions—Range in six females and ten males all without obvious immaturity: Head and body, 71-87; 70-86. Tail, 71-83; 75-87. Pes, 16-17.5; 16-19. Ear, 13-15; 12.5-15.5.

Skull—Range of dimensions in six unsexed adults: Greatest length, 21.3-23.5. Basal length, 18.1-20.5. Zygomatic breadth, 10.9-11.9. Braincase breadth, 10.0-10.3. Nasals, length, 7.6-8.6. Nasals, breadth, 2.1-2.5. Inter-orbital constriction, 3.7-3.9. Palatal length, 11.1-12.2. Anterior palatal foramina, 5.0-5.2. Bullae, 3.5-4.1. Upper molar series, 3.4-3.9.

The molar wear is remarkably high; in several individuals of less than half growth the crowns are already flat.

No reliable evidence of the presence of either *Rattus rattus* or *Rattus norvegicus* was obtained.

Of other introduced mammals the rabbit, fox and feral cat occur in all parts of the area. It is noteworthy that since the immense mortality of 1905, the rabbit does not appear to have undergone periodic increase and decline as it does in the areas further west; during the whole period of murid increase from 1930-1935 its numbers remained unaltered and comparatively low.

In 1935 large numbers of feral cats were reported from several localities in the area. At Appamunna their maximum occurred in June, at a time when murids, and indeed all mammals, were at a low ebb.

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EXPLANATION OF PLATES IV AND V
illustrating adult *Muridae* from the Lake Eyre Basin

PLATE IV

- A *Leporillus conditor* var. ♀ Right pes x 1.3 ca.
- B *Leporillus conditor* var. ♀ Right manus x 2 ca.
- C *Rattus villosissimus villosissimus* Waite ♂ Right pes x 1.4 ca.
- D *Rattus villosissimus villosissimus* Waite ♂ Right manus x 2 ca.
- E *Pseudomys (Pseudomys) minnie* Troughton ♀ Right pes x 1.6 ca.
- F *Pseudomys (Pseudomys) minnie* Troughton ♀ Right manus x 2 ca.
- G *Notomys aistoni* Brazenor ♀ Right pes x 1.4 ca.
- H *Notomys aistoni* Brazenor ♀ Right manus x 3 ca.
- I *Notomys cervinus* (of Waite) ♂ Right pes x 1.4 ca.
- J *Notomys cervinus* (of Waite) ♂ Right manus x 3 ca.
- K *Mus musculus* var. ♀ Right pes x 2.3 ca.
- L *Mus musculus* var. ♀ Right manus x 2.7 ca.
- M *Pseudomys (Leggadina) cf. forresti* Thomas var. ♂ Right pes x 2 ca.
- N *Pseudomys (Leggadina) cf. forresti* Thomas var. ♂ Right manus x 3 ca.
- O *Notomys cervinus* (of Waite) ♂. The gular area, to show the external appearance of the gland site. The gular and ventral surfaces are in the same plane, and the surrounding fur has been artificially parted away from the gland
- P *Notomys aistoni* Brazenor ♂ As in O

PLATE V

- A, B, C Aspects of the skull of *Leporillus conditor* ♀ x 1 ca.
- D, E, F Aspects of the skull of *Rattus villosissimus villosissimus* Waite ♂ x 1 ca.
- G, H, I Aspects of the skull of *Pseudomys (Pseudomys) minnie* Troughton ♂ x 1 ca.
- J, K, L Aspects of the skull of *Notomys cervinus* (of Waite) ♀ x 1.3 ca.
- M, N, O Aspects of the skull of *Notomys aistoni* Brazenor ♀ M x 1.4 ca.; N + O x 1.1 ca.
- P, Q, R Aspects of the skull of *Mus musculus* var. ♂ x 1.2 ca.

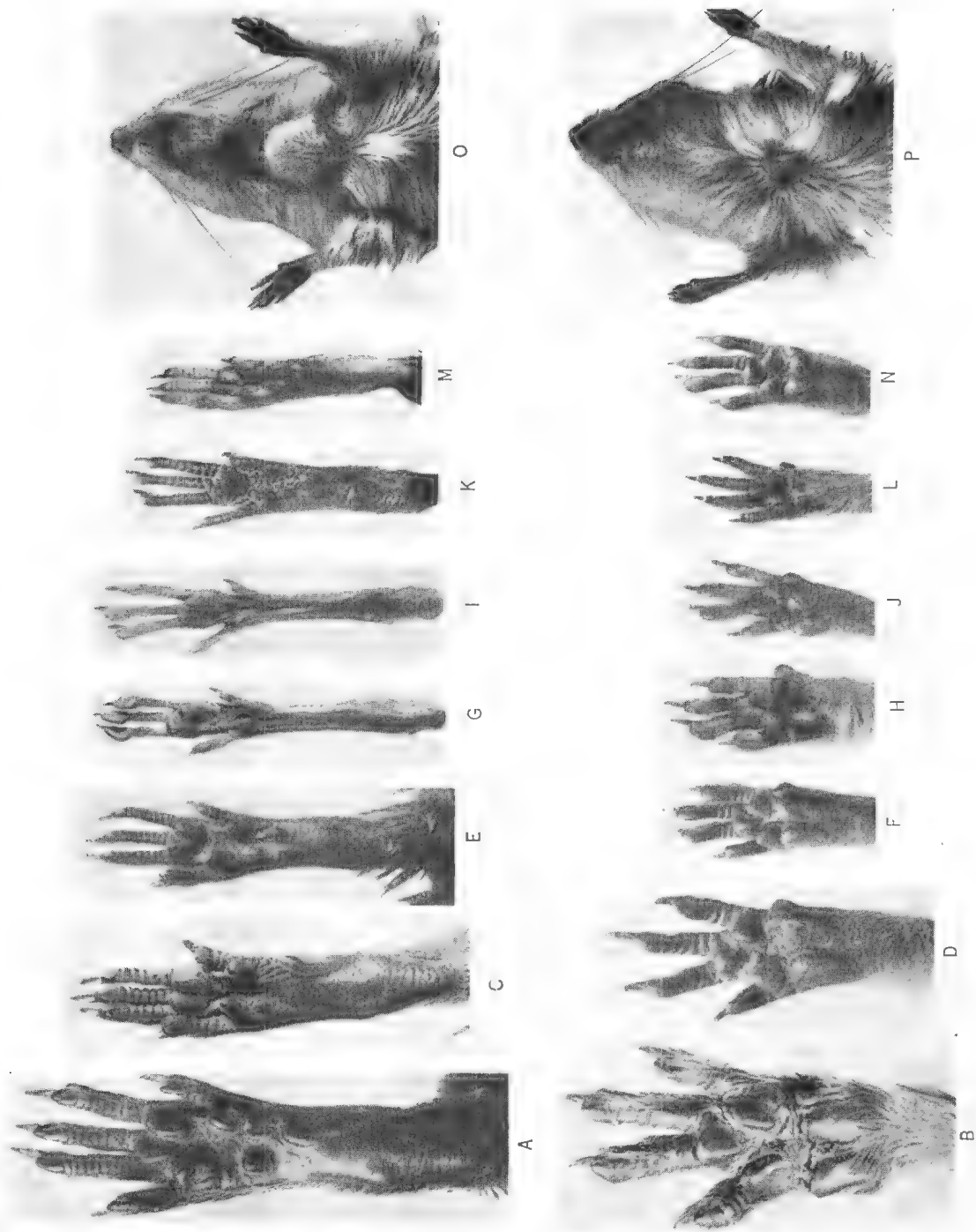
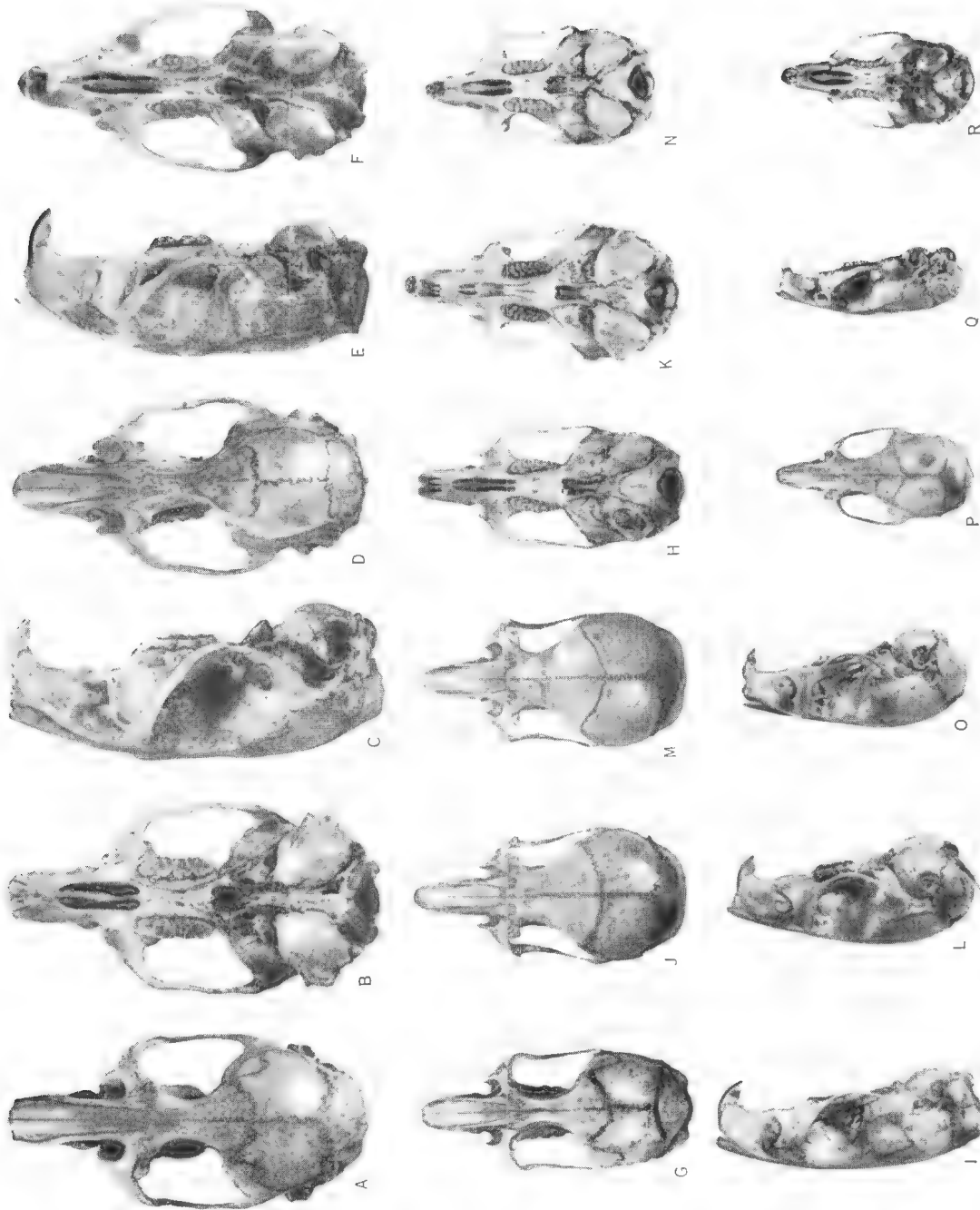


Photo by H. H. Finlayson



ABORIGINAL ARRANGEMENT OF STONES AT MOANA, SOUTH AUSTRALIA

By C.P. MOUNTFORD, Acting Ethnologist, South Australian Museum

Summary

During recent years, stones arranged in a definite pattern on gibber pavements and claypans have been recorded from various parts of Australia. Many of these are known to be the work of aboriginal people, and their mythology and use have been described. (Elkin, 1938, p.128, and Campbell and Mountford, 1939, p 17.)

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[Read 25 May 1939]

PLATE VI

During recent years, stones arranged in a definite pattern on gibber pavements and claypans have been recorded from various parts of Australia. Many of these are known to be the work of aboriginal people, and their mythology and use have been described. (Elkin, 1938, p. 128, and Campbell and Mountford, 1939, p. 17.)

This paper describes a similar example of arranged stones that existed for many years at Moana, at a spot some fifty yards south of Peglar's Creek and about fifty feet above high water mark.

During 1926 Mr. P. Stapleton and I examined this arrangement in detail and submitted our findings to the October meeting of the Royal Society in 1927. Owing to lack of corroborative evidence, however, the paper was not published. Since then a considerable amount of information regarding these curious examples of aboriginal handiwork has been gathered. As the combined efforts of campers and roaming cattle have almost completely destroyed this example, and the description prepared by Mr. Stapleton and myself is the only record available, it was decided to submit this short paper.

At the time of our investigation, the stone pattern was 108 yards in length and 35 yards across the greatest width. The arrangement occupied a low ridge, which was about five feet above high water mark and an adjacent clay flat, both of which were lightly covered with a thin layer of drift sand.

The lines were almost entirely composed of waterworn pebbles, placed end on end, which had been collected from the myriads that were distributed over the surface. In some of the lines, however, pieces of travertine, and in two places aboriginal core stones, had been used. Drifting sandhills (shown by dotted areas) apparently covered a portion of the arrangement.

As Mr. Stapleton and I had no instruments or necessary knowledge to survey the area, we adopted the laborious but nevertheless accurate method of setting out the surface in 10-foot squares with string. The designs within each square were plotted on graph paper, from which text fig. 1 was prepared.

The arrangement consisted of long meandering lines, circles, and loops. In some parts the pebbles were badly scattered, while in others, particularly at A, fig. 1, the lines were almost complete. (See also fig. 2, pl. vi). At C and D, fig. 1, were piles of stones that suggested small collapsed cairns, such as have been recorded by Wood Jones, 1925, and Campbell and Mountford, 1939. Figure 1, pl. vi, was taken in a southerly direction from B, fig. 1, and shows a general view of the area looking south.

The surrounding country still bears ample evidence of aboriginal occupation. Many skeletons have been found in the sandhills in the background of fig. 1, pl. vi, and the surfaces of many of the sanddrifts, as well as adjacent clay flats, are strewn with large numbers of discarded stone flakes. Many implements, hammer stones, cores, and a few engraved pebbles⁽¹⁾ have also been collected from the same locality.

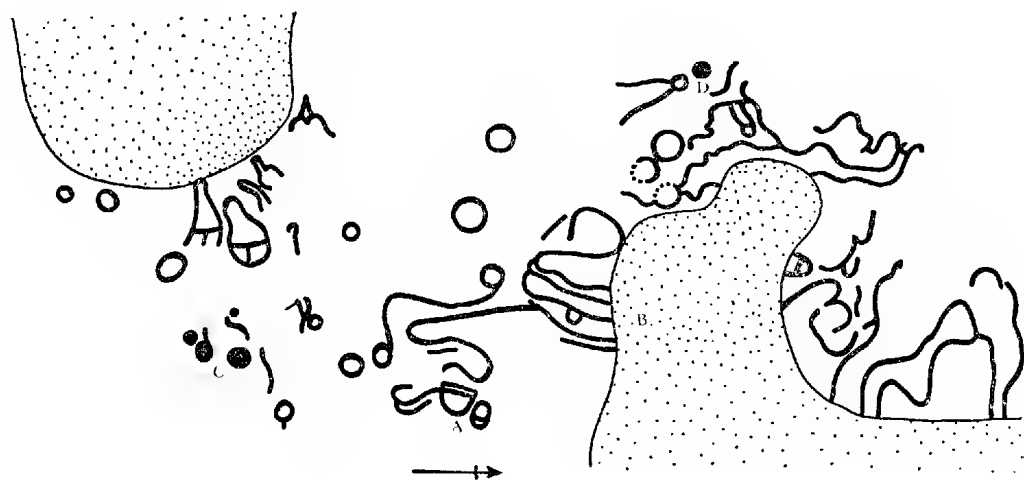


Fig. 1

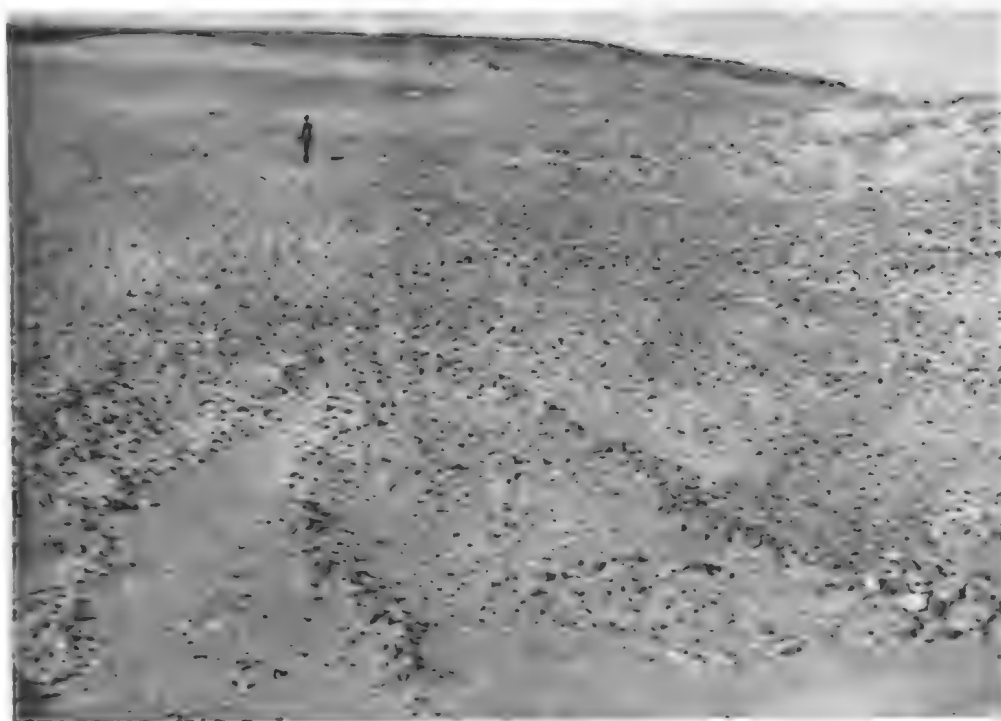
DISCUSSION

There is no direct evidence regarding either the use or significance of the stone arrangements. The fact, however, the situation is adjacent to a locality that bears ample evidence of aboriginal occupation and that the arrangement and general pattern of the lines of stones are similar to other recorded examples, and to those seen by me on Simpson's Desert, would suggest that they are the work of aborigines, in all probability, those of the extinct Adelaide tribe. In other parts of Australia such arrangements are associated with totemic beings and often with the increase ceremonies. It is possible that the Moana examples would have a similar use.

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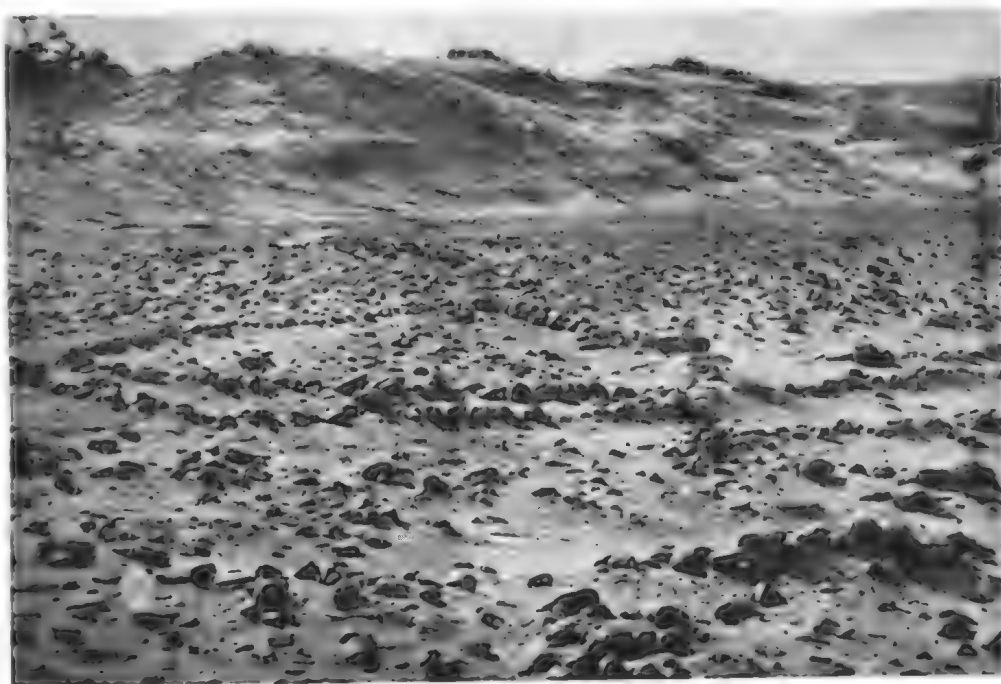
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⁽¹⁾ See C, fig. 1, Engraved Pebbles from South Australia of Unknown Significance, Mountford, 1938, p. 146



Photo, C. P. Mountford

Fig. 1 General view of arranged stones, Moana, looking south



Photo, C. P. Mountford

Fig. 2 View of arranged stones, Moana, Group A

STRONGYLE NEMATODES FROM QUEENSLAND MARSUPIALS

By T. HARVEY JOHNSTON and P. M. MAWSON, University of Adelaide

Summary

The present paper is the fourth of a series dealing with the nematode parasites of Australian marsupials (1938, a, b, c). Most of the material has been collected from the stomach, from which situation all the specimens were found to belong to genera of Strongylidae, Triclioneminae. The few specimens taken from the intestine belong to *Globocephaloides*, and the finding of males, previously unknown, has permitted the addition of male characteristics to the generic diagnosis and the assignment of the genus to the Strongylinae. Three new genera, *Papillostrongylus*, *Coronostrongylus* and *Buccostrongylus* have been proposed. Cobb's *Zoniolaimus*, based on some minute figures and formulae but without any other description, has been rehabilitated, *Labioststrongylus* being regarded as a synonym of it. The collection studied has been brought together by the senior author over a period of thirty years.

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The present paper is the fourth of a series dealing with the nematode parasites of Australian marsupials (1938, a, b, c). Most of the material has been collected from the stomach, from which situation all the specimens were found to belong to genera of Strongylidae, Trichoneminae. The few specimens taken from the intestine belong to *Globocephaloides*, and the finding of males, previously unknown, has permitted the addition of male characteristics to the generic diagnosis and the assignment of the genus to the Strongylinae. Three new genera, *Papillostrongylus*, *Coronostrongylus* and *Buccostrongylus*, have been proposed. Cobb's *Zoniolaimus*, based on some minute figures and formulae but without any other description, has been rehabilitated, *Labiostongylus* being regarded as a synonym of it. The collection studied has been brought together by the senior author over a period of thirty years.

Acknowledgment is made of the assistance rendered by Dr. F. H. S. Roberts, Parasitologist, Stock Department, Brisbane; and especially by the late Dr. T. L. Bancroft, of Eidsvold, and by his daughter, Dr. M. J. Mackerras. The investigation has been made possible by the Commonwealth Research Grant to the University of Adelaide.

The types of all new species have been deposited in the South Australian Museum, Adelaide.

LIST OF NEMATODES REFERRED TO IN THIS PAPER, ARRANGED UNDER THEIR HOSTS
Macropus major Shaw. *Pharyngostrongylus macropodis* Y. and M.; *Zoniolaimus bipapillosus* n. sp.

Macropus dorsalis Gray. *Pharyngostrongylus gamma* n. sp.; *P. delta* n. sp.; *P. epsilon* n. sp.; *P. zeta* n. sp.; *Zoniolaimus uncinatus* n. sp.; *Cloacina bancroftorum* n. sp.; *C. burnettiana* n. sp.; *C. longispiculata* n. sp.; *Cloacina* sp.; *Buccostrongylus buccalis* n. sp.; *Papillostrongylus labiatus* n. sp.; *Globocephaloides wallabiae* n. sp.; *G. affinis* n. sp.

Macropus parryi Bennett. *Pharyngostrongylus macropodis* Y. & M.; *P. gamma* n. sp.; *P. brevis* Canavan; *Macropostrongylus yorkei* Baylis; *Zoniolaimus bancrofti* n. sp.; *Cloacina communis* J. & M.; *Buccostrongylus buccalis* n. sp.

Macropus agilis Gould. *Cloacina roberisi* n. sp.; *C. longispiculata* n. sp.; *C. macropodis* J. & M.; *Macropostrongylus macropostrongylus* Y. & M.; *Cloacina* sp.

Macropus tatei Longman. *Zoniolaimus insularis* n. sp.; *Macropostrongylus macropostrongylus* Y. & M.; *M. yorkei* Baylis; *Cloacina macropodis* J. & M.; *Cloacina* sp.

Macropus thetidis Lesson. *Pharyngostrongylus zeta* n. sp.; *Buccostrongylus australis* n. sp.; *Coronostrongylus coronatus* n. sp.

Macropus wilcoxi McCoy. *Zoniolaimus communis* n. sp.; *Buccostrongylus buccalis* n. sp.; *B. australis* n. sp.; *Coronostrongylus coronatus* n. sp.; *Cloacina macropodis* J. & M.

Macropus ualabatus Lesson & Garnot. *Zoniolaimus communis* n. sp.

Macropus apicalis Gunther. *Zoniolaimus uncinatus* n. sp.; *Cloacina similis* n. sp.; *Cloacina* sp.

Macropus sp. (from Millmerran, Darling Downs). *Zoniolaimus communis* n. sp.; *Pharyngostrongylus eta* n. sp.

Petrogale penicillata Gray. *Pharyngostrongylus zeta* n. sp.; *P. alpha* J. & M.; *Cloacina similis* n. sp.; *C. robertsi* n. sp.

Onychogale frenata Gould. *Zoniolaimus onychogale* n. sp.

Isoodon obesulus Shaw. *Cloacina* sp.

Macropus sp. from Millmerran is a wallaby. It is probably either *M. ruficollis* or *M. dorsalis*, the former species being stated by Le Souef and Burrell ("The Wild Animals of Australia," 1926) to occur "in drier forest country" and the latter "in rough open country." *M. ruficollis* seems to be the more likely species. Wood Jones (Mammals of South Australia, pt. ii, 1924, p. 245) states that the name *M. ruficollis* Desmarest should be restricted to the form from King Island, Bass Strait, and that *M. rufogriseus* Desm. is the correct name for the mainland species. This same author (*l.c.* p. 247) points out that *Macropus (Wallabia) bicolor* Desm. has priority over *M. ualabatus (typicus)* Less. & Garn.

We take the opportunity to make some corrections in regard to host names contained in our earlier papers. When dealing with *Dipetalonema roemeri*, we mentioned (1938 a) *Macropus ualabatus* (Hawkesbury River) amongst the hosts on page 107 but omitted it from the list on page 111; *M. ruficollis* was given on page 111 but omitted from page 107, the locality being the Blue Mountains, New South Wales. We have been informed by Dr. Roberts that *Macropus* sp. from Inverleigh, Carpentaria, the animal from which *Dipetalonema annulipapillatum* was recorded by us (1938 c, 189) is *M. agilis*. In the same paper we described *Austroxyuris finlaysoni*, *Passalurus parvus* and *Oxyuris acuticaudata* from the flying opossum, *Petauroides volans*, the variety being indicated on the original label as *minor*. Mr. Finlayson, in his account of the mammals of the Dawson and Fitzroy River valleys (Trans. Roy. Soc. S. Aust., 58, 1934, 219), has identified the host specimen as var. *incanus* Thomas.

ZONIOLAIMUS Cobb, 1898

The author did not give a diagnosis of the genus nor any verbal account of the two species which he named. The only information is contained in a very small figure of one of them (*Z. scitifera*) and of the genital system of the other (*Z. brevicaudatus*), together with the "formula" of one sex for each. The host of the former was given as the brush wallaby from Moss Vale, New South Wales. This animal was *Macropus ualabatus*. The host of the other parasite was not indicated, but the material was probably also obtained from the same species of

marsupial. Railliet thought that the genus might be synonymous with *Cloacina*. Yorke and Maplestone (1926), as well as Baylis and Daubney (1926), gave brief diagnoses based on Cobb's figures.

We have examined a number of species which are congeneric with *Zoniolaimus* and now place *Labiostrongylus* Yorke and Maplestone as a synonym of it. The structure of the lips and of the bursa is similar in both. The setae, which are such a striking feature of *Z. setifera*, are present on all the described species of *Labiostrongylus*, though not so highly developed. The lengths stated by Cobb for one of his species (*brevicaudatus*) are incompatible with the figures.

The following diagnosis of the genus is based largely on that given for *Labiostrongylus* by Yorke and Maplestone (1926).

Trichoneminac—Mouth directed straight forwards; surrounded by six to eight processes; submedian largest and may or may not be bilobed; laterals simple; ventral and dorsal, if present, quite small and conical. Buccal capsule large, cylindrical, heavily chitinated. Oesophagus long, slender, surrounded at its base by one or more pairs of lateral pouches from intestine.

Male—Bursa large; lobes clearly defined; ventral lobes usually separate. Ventral rays together, parallel; externo-laterals and externo-dorsals shorter than laterals (with which they arise) and usually lifting lateral wall of the bursa. Laterals long, parallel. Dorsal ray usually stout, ending in two branches lying in lappets of dorsal lobe; one pair of lateral rays given off either from main stem or a ray from each of the two branches. Genital cone usually prominent; accessory cone present. Spicules thin, with striated alae and simple points. Gubernaculum present or absent.

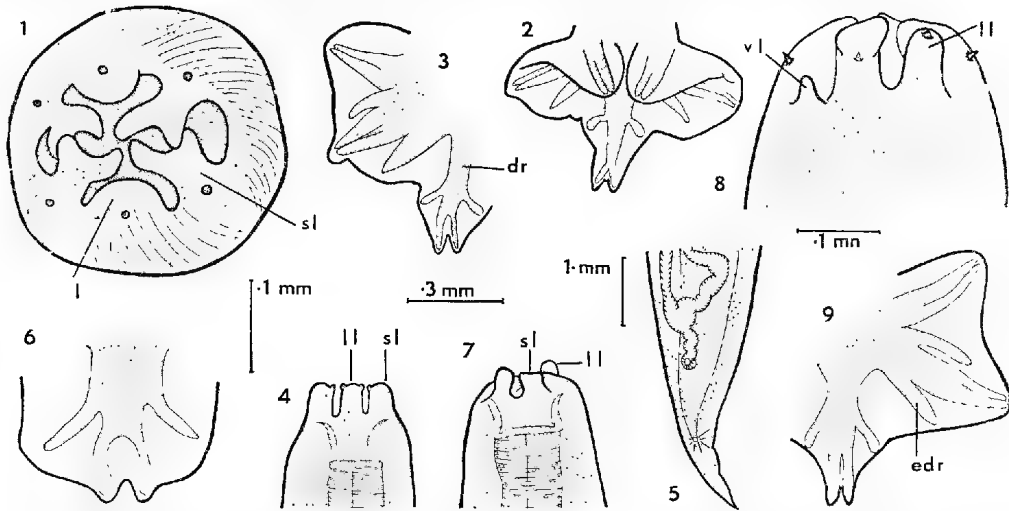
Female—Body posterior to vulva narrowing to a pointed tail. Uteri parallel; vagina varying in length, usually twisted; vulva not far in front of anus; the distance between vulva and anus not greater than that from anus to tip of tail. Eggs relatively small. From stomach of marsupials. Type, *Z. setifera* Cobb, 1898, from a "brush wallaby" (*Macropus ualabatus*). Other species: *Z. brevicaudatus* Cobb, 1898, host not stated but probably *M. ualabatus*; also the following species originally described under *Labiostrongylus*: *Z. labiostrongylus* (Y. and M., 1926), *Z. longispicularis* (Wood, 1929), *Z. macropodis* (Johnston and Mawson, 1938), *Z. grandis* (Johnston and Mawson, 1938), *Z. petrogale* (Johnston and Mawson, 1938). Six new species are proposed in the present paper: *Z. bancrofti* from *Macropus parryi*; *Z. bipapillosus* from *M. major*; *Z. communis* from *M. ualabatus*, *M. wilcoxi* and *M. sp.* from Millmerran; *Z. insularis* from *M. zvelsbyi*; *Z. uncinatus* from *M. dorsalis* and *M. apicalis*; and *Z. onychogale* from *Onychogale frenata*.

***Zoniolaimus bancrofti* n. sp.**

Figs. 1-2

From *Macropus parryi*, near Eidsvold, Upper Burnett River, collected by the late Dr. T. L. Bancroft.

Stout worms. Males, about 30-33 mm. long and 1 mm. wide; females, 31-45 mm. long by 1.5 mm. broad. Head surmounted by six lips; four submedian lobed, each bearing proximally a small rounded papilla with bristle; the two laterals simple, distal part of each rather larger and bearing small papilla. Anterior end of oesophagus 0.2 mm. from top of lips; chitinated wall of buccal capsule 0.12 mm. deep. Oesophagus 7.35 mm. long (1:4.4 of body length) in male; 10 mm. (1:4.4 of body length) in female; widening gradually towards base; posterior end surrounded by a pair of lateral lobes from intestine.



Figs. 1-2, *Zoniolaimus bancrofti*: 1, Anterior view of head; 2, Ventral view of bursa. Figs. 3-5, *Zoniolaimus bipapillatus*: 3, Right part of bursa; 4, Lateral view of head; 5, Posterior end of female. Figs 6-7, *Zoniolaimus communis*: 6, Dorsal ray of bursa; 7, Head. Figs 8-9, *Zoniolaimus insularis*: 8, Head; 9, Left part of bursa. Figs. 1 and 5 to same scale; 2, 3, 4, 7 and 9 to same scale.

REFERENCES TO LETTERING

a, anus; ac, accessory genital cone; br, buccal ring; cp, cervical papilla; dp, dorsal papilla; dr, dorsal ray; edr, externo-dorsal ray; ep, excretory pore; gc, genital cone; ll, lateral lip; lp, lateral papilla; nr, nerve ring; p, prebursal papilla; s, spicule; sl, submedian lip; sp, submedian papilla; t, tooth; v, vestibule; vl, ventral lip; vr, ventral ray; vu, vulva.

Male—Spicules rather short, 3.66 mm. long, 1:9 of body length; with narrow alae; small irregular gubernaculum. Bursa large, with long prominent dorsal lobe; laterals wide; ventrals not joined to one another. Ventral rays cleft for half length and reaching almost to edge of ventral lobe; externo-lateral extending to edge of junction between ventral and lateral lobes; laterals long, parallel, cleft for nearly all length; externo-dorsal shorter, arising from same base as laterals. Dorsal ray stout; giving off near mid-length two short club-shaped lateral branches reaching edge of bursa near beginning of dorsal lobe; main dorsal ray passing on, narrowing until near its base, then dividing into two short branches, each of these extending into one of the two terminal lappets of the dorsal lobe.

Female—Body posteriorly to anus narrowing greatly to end in thin pointed tail. Vagina very short, narrow, coiled; distance from junction of ovejectors to vulva 0.8 mm.; vulva 1.15 mm. from anus; anus 1.12 mm. from tip of tail.

The species resembles *Z. labiostrongylus* in general proportions, but differs in the form of the externo-lateral and externo-dorsal rays, the character of the dorsal ray, and in the absence of dorsal and ventral lips.

***Zoniolaimus bipapillosus* n. sp.**

Figs. 3-5

From stomach of *Macropus major*, Upper Dawson Valley (coll. Dr. Bancroft). Long, stout worms. Males, 28-37 mm. long; females, about 50 mm. Six lips; two laterals each with pair of small rounded papillae; submedians simple, each with ridge on inner edge facing mouth cavity. Buccal capsule 0.12 mm. deep by 0.1 mm. wide; with strongly chitinated walls and floor. Oesophagus 12-12.5 mm. long, 1:3-4 of body length; beginning 0.28 mm. from top of lips. Nerve cord and excretory pore not recognised in the poorly cleared specimens available.

Male—Spicules about 4.3 mm. long, 1:7.4-9 of body length; thin, straight; with striated alae. Bursa large, dorsal lobe long. Ventral rays cleft for most of length, parallel, extending nearly to edge of bursa. Externo-lateral and externo-dorsal rays of equal length and distinctly shorter than laterals with which they arise; laterals cleft for most of length, and passing out almost to edge of bursa which is wider just at this part. Dorsal ray stout, giving off near half its length two lateral branches, extending outwardly nearly to edge of bursa; main dorsal ray passing into longest part of dorsal lobe, and soon dividing into two branches, each terminating in a lappet of the lobe.

Female—Body narrowing near region of vulva to end in pointed, tapering tail. Uteri parallel; ovejectors short; vagina very short, twisted; vulva 2.5 mm. from posterior end and 1.2 mm. in front of anus.

The specific name is given on account of the presence of two papillae on each lateral lip. This species shows resemblance to *Z. bancrofti* in regard to the length of spicules, but differs in the form of the dorsal ray, arrangement of the lips, and length of the vagina.

***Zoniolaimus communis* n. sp.**

Figs. 6-7

From stomach of *Macropus ualabatus* (type host) and *M. wilcoxi*, Upper Burnett River (coll. Dr. Bancroft).

Shorter than most Labiostrongyles; male 15.5 mm.; female 16-34 mm. They all tend to be more or less coiled, especially in the tail region. Head with six lips; two laterals shortest, rounded, each with small rounded papilla on upper end; four submedians large, simple, each with thin conical papilla near its base. Buccal capsule about 0.13 mm. in diameter in female; with chitinous walls about

0.1 mm. deep, base 0.16 mm. from anterior end. Oesophagus narrow, relatively long, 7 mm. long in female, one-third of body length; 4.5-5.5 mm. in male, one-fifth body length; around posterior end a dark mass, probably paired intestinal lobes. Nerve ring about 0.6 mm., and excretory pore 0.75 mm. from anterior end in male. Cuticle finely striated transversely.

Male—Spicules 4.75 mm. long, 1:3.2 of body length; thin; with very narrow alae and pointed tips. Bursa hard to observe satisfactorily, as it is short and not easily spread out. Ventral lobes separate; dorsal lobe not so much prolonged as in other species. Ventral rays parallel, cleft for most of length, bent so as to penetrate into ventral corners of ventral lobes. Externo-lateral ray very thin, short; externo-dorsal short; laterals long, extending to edge of bursa. Dorsal ray very wide, short; after half its length giving off a long lateral on each side, the main stem soon afterwards dividing into two branches, each projecting into pocket at edge of bursa. Genital cone short.

Female—Body narrowing towards posterior end, more suddenly after anus, to terminate in short pointed dorsally-directed tail. Uteri parallel; ovejectors short, stout; vagina fairly long, twisted, full of very small eggs. Anus 1.1 mm. from tip of tail; vulva 0.65 mm. in front of anus. Eggs 0.11 by 0.08 mm.

This species differs from other six-lipped forms in the characters of the dorsal ray and in the relatively short length of the worm. The nearest ally seems to be *Z. longispicularis*, from which it differs in regard to the dorsal ray, body length, shortness of vagina and the presence of posterior submedian papillae on the lips.

Zoniolaimus insularis n. sp.

Figs. 8-9

From stomach, *Macropus tvelsbyi*, Stradbroke Island.

Male 43-44 mm. long, breadth 1.5 mm.; female about 50 mm. long, 3 mm. broad. Eight lips; submedians lobed, each with small conical papilla, laterals simple with small rounded papilla; dorsal and ventral lips very short. Buccal capsule 0.1 mm. long by 0.14 mm. broad, base 0.25 mm. distant from anterior end of lips. Oesophagus 10-11 mm. long in male, 1:3.4-4.4 of body length; 15 mm. in female, 1:3.4 of body length; narrow. Intestinal lobes which more or less surround the base of the oesophagus in species of *Zoniolaimus* are practically absent in this form. Nerve cord not more than 1.7 mm.; excretory pore at about 1.7 mm.; and cervical papillae at 1.15 mm. from anterior end.

Male—Bursa large; ventral lobes separate, dorsal lobe prolonged. Externo-lateral and externo-dorsal rays arising with laterals; externo-dorsal extending almost to edge of lateral lobe; laterals long, dividing at half length and extending nearly to bursal edge. Dorsal ray giving off at about half length a short branch from each side, main stem passing on to subdivide into two subequal, fairly long rays projecting each into a distinct lappet of the bursa. Spicules 4.5-5.5 mm.; 1:8.8-9.4 of body length; with striated alae almost to tips; tips pointed and separate.

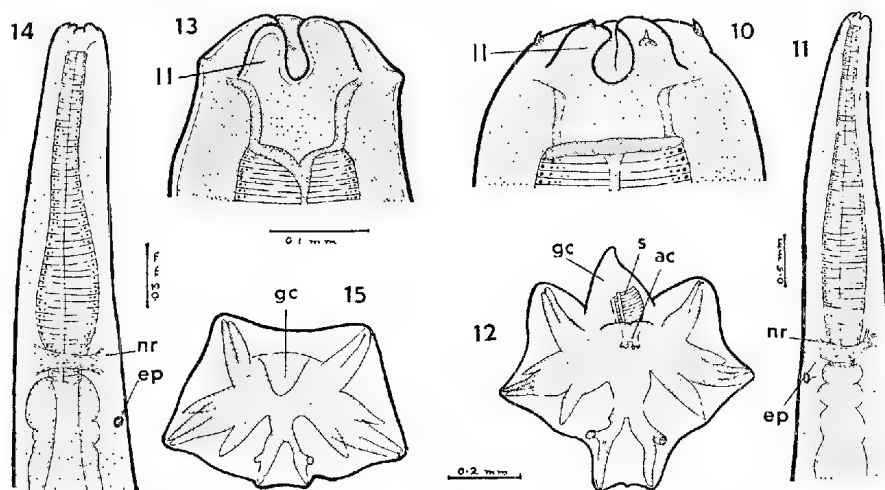
Female—Uteri large, parallel; parts of ovejectors distinct, muscular; vagina short, twisted; vulva 1·7 mm. in front of anus, and 3·6 mm. from posterior end; anus about midway between vulva and tip of tail.

This species is close to *Z. labiostrengylus*, but shows slight differences in the length of spicules and oesophagus, branching of dorsal ray, longer externo-lateral and externo-dorsal rays, position of papilla on each submedian lip (as indicated in Yorke and Maplestone's figure), and in the presence of a papilla on each lateral lip (not mentioned by these authors).

***Zoniolaimus uncinatus* n. sp.**

Figs. 10-12

From *Macropus dorsalis* (type host), Upper Burnett River (coll. Dr. Bancroft), and Botanical Gardens, Brisbane; also from *Macropus apicalis* (female worms only) from the Upper Mary River, near Woolooga.



Figs. 10-12. *Zoniolaimus uncinatus*: 10, Head; 11, Anterior end; 12, Posterior view of bursa. Figs. 13-15, *Zoniolaimus onychogale*: 13, Head; 14, Anterior end; 15, Posterior view of bursa. Figs. 10 and 13 to same scale; figs. 12 and 15.

Worms short for this genus: male 19-22 mm.; female 27-35 mm. Head rounded; six lips, each submedian with a prominence at half length provided with a hook-like papilla (hence specific name); laterals each with small rounded papilla near apex; submedians large but not bilobed distally. Buccal capsule quite shallow, 0·05 mm. deep, 0·1 mm. wide; base 0·13 mm. from top of lips. Oesophagus about 3 mm. long (1:7-8 of body length); of distinctive shape, last two-thirds about twice as wide as first third; thicker part quite distinct to naked eye, being much darker than the rest of the alimentary canal. Around posterior end of oesophagus is a band of tissue, probably the nerve ring. Just behind the latter is the excretory pore. Cervical papillae stiff, bristle-like; at 1·5 mm. from anterior end in male.

Male—Bursa large; ventral lobes separate; dorsal lobe long, squarish, with free end forming three lappets. Ventral rays cleft for about half length; externo-lateral short, thin; laterals cleft for half length; externo-dorsal arising with laterals, stout, long. Dorsal ray stout; dividing before half its length into two branches, each soon giving off a short lateral ray before proceeding to the edge of bursa; one branch occupying each lateral lappet of the dorsal lobe; the lateral ray directed dorsally. Spicules straight; stout; 2.4–2.6 mm. long, 1:8–9 of body length; with very wide striated alae ending near tips which are joined. Genital cone well developed; accessory cone ending in two short, relatively wide processes, each indented at tip.

Female—Uteri parallel; ovejectors muscular, spindle-shaped; vagina straight, narrow, with small eggs, 0.06 mm. by 0.12 mm. Vulva about 2.4 mm., and anus 1.35 mm. from posterior end. Tail long, tapering.

This species differs from other Labiostrongyles in the form of the dorsal ray, shape of the oesophagus, and position of the nerve ring, excretory pore and cervical papillae.

***Zoniolaimus onychogale* n. sp.**

Figs. 13–15

From stomach of *Onychogale frenata*, Upper Burnett River (coll. Dr. Bancroft).

Short stout worms closely resembling *Z. uncinatus*, both externally and internally, but differing chiefly in the length of spicules, though there are also slight differences in the shape of the female tail, the dorsal lobe of the bursa, the depth of the buccal capsule, and the form and position of the lip papillae. Males about 11 mm.; females 24–26 mm. Six lips; submedians with prominence near base, representing broad low papilla; laterals with small median papilla near anterior edge. Buccal capsule strongly chitinated, 0.06 mm. deep by 0.08 mm. wide. Oesophagus about 1.45 mm. long, posterior half wider. Nerve ring surrounding base of oesophagus; excretory pore posterior to end of oesophagus; this region of body very closely resembling that of *Z. uncinatus*.

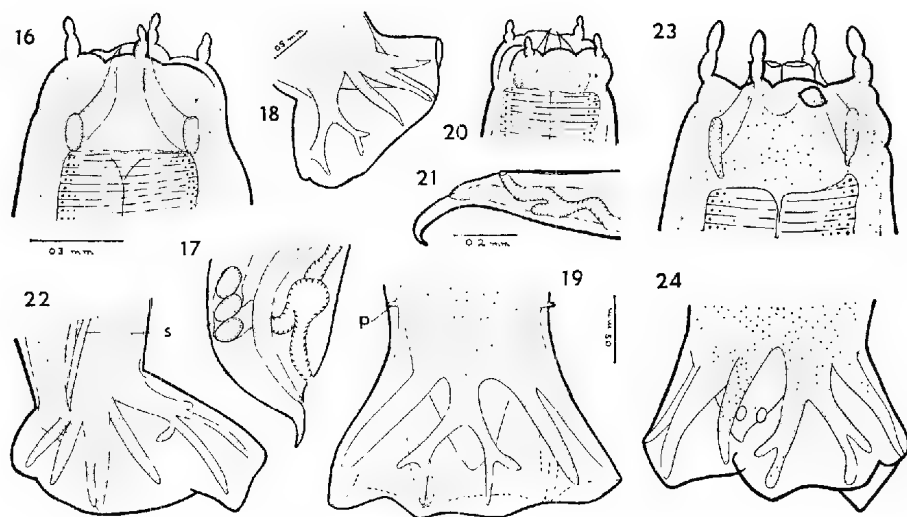
Male—Bursa large; dorsal lobe not so long as in *Z. uncinatus*. Ventral rays long, parallel; externo-laterals short; laterals long, cleft for most of length; externo dorsal arising with laterals, but shorter; dorsal ray bifurcated at about end of first third, each branch giving off short lateral at about half way. Spicules long, 4.2 mm., 1:2.6 of body length; very thin. Gubernaculum present; genital cone large; accessory cone not seen because of condition of specimen.

Female—Body stout, narrowing suddenly after vulva; rather long tapering tail curved dorsally. Anus 1.4 mm. from the tip; vulva 0.7 mm. in front of anus. Uteri parallel; ovejectors long; vagina narrow, short. Eggs in vagina 0.16 mm. by 0.09 mm.

Genus CLOACINA Linstow, 1898

This genus does not appear to be nearly so well represented in Queensland marsupials as in those of Central Australia. We have recently (1938 b) given a diagnosis. Five new species are now described: *Cloacina bancroftorum* and *C. burnettiana* from *Macropus dorsalis*; *C. similis* from *M. apicalis* and *Petrogale penicillata*; *C. robertsi* from *M. agilis* and *Petrogale penicillata*; *C. longispiculata* from *M. dorsalis* and *M. agilis*.

Two recently described species, *C. communis* and *C. macropodis* J. & M., were recognised amongst Queensland material.



Figs. 16-19, *Cloacina robertsi*: 16, Head (male); 17, Posterior end of female; 18, Dorsolateral view of bursa; 19, Dorsal view of bursa. Figs. 20-22, *Cloacina burnettiana*: 20, Head of female; 21, Posterior end of female; 22, Dorsolateral view of bursa. Figs. 23-24, *Cloacina similis*: 23, Head of female; 24, Dorsolateral view of bursa. Figs. 16, 20 and 23 to same scale; figs. 21 and 22; figs. 19, 22, and 24.

***Cloacina robertsi* n. sp**

Figs. 16-19

From the rock wallaby, *Petrogale penicillata* (type host), Upper Burnett River (coll. Dr. Bancroft); and *Macropus agilis*, Gregory River, North Queensland (coll. Dr. Roberts).

Fairly robust worms; male 5.5-11 mm.; female 6.0-9.8 mm. Six lips, each submedian with a two-jointed papilla whose upper segment is the smaller. Cuticle constricted slightly at base of lips. Buccal capsule very shallow, about 0.01 mm. deep and 0.034 mm. in diameter, well set back from anterior end of worm, so that its base is 0.03 mm. from oral opening. Leaf crown of six elements arising from base of capsule, tips pointed and surrounding small mouth aperture 0.008 mm. in diameter. Oesophagus short; 0.42-0.5 mm. in male (1:13-20 of

body length); 0.4-0.48 mm. in female (1:20.4-21.5 of body length); widened at base but without definite bulb. Nerve ring at 0.2-0.3 mm. from anterior end, surrounding oesophagus just behind mid-length; excretory pore near posterior end of oesophagus. Cervical papillae at 0.08-0.11 mm. from anterior end; long; threadlike.

Male—A pair of prebursal papillae. Bursa large; lobes not deeply separated; ventral lobes continuous. Ventral rays thin, parallel, reaching edge of bursa. Externo-lateral and externo-dorsal arising from same root as, and a little shorter than, laterals; latter thin, parallel, cleft for most of length, and almost reaching bursal edge. Dorsal ray bifurcating at about one-third length, each branch passing outwards and downwards and giving off at about mid-length a shorter lateral ray, no terminations reaching bursal edge. Genital cone large. Spicules very long, 2.3-5.65 mm., 1:2-2.4 of body length, thin, with striated alae and long pointed tips.

Female—Body narrowing suddenly just posteriorly from vulva; short backwardly-directed pointed tail. Uteri parallel; vagina very short; vulva 0.16-0.3 mm., and anus 0.07-0.15 mm. from posterior end; eggs large, 0.11 by 0.06 mm.

This species resembles *C. macropodis* in general anatomy and length of spicules, but differs in the shape and size of the papillae, buccal capsule and lips. It also resembles *C. curta* J. & M., but differs from it in regard to the oesophagus, dorsal ray and length of vagina.

***Cloacina burnettiana* n. sp.**

Figs. 20-22

From stomach of *Macropus dorsalis*, Upper Burnett River (coll. Dr. Bancroft). Thin; very short; male 2.35-3 mm.; female 3.1 mm.; body narrowing towards head; extreme anterior end rather enlarged to give rise to eight wide shallow lips, the four submedians each with a two-jointed papilla, 0.01 mm. high. Buccal capsule 0.017 mm. in diameter, with thick walls 9 μ high; leaf crown of six elements arising from base of capsule and bent inwards, nearly closing mouth opening. Oesophagus short; 0.39-0.42 mm. long (1:6-7 of body length) in male; 0.3 mm. (1:10 of body length) in female; wide, generally enlarging towards base, latter not markedly bulbous; anterior end 0.015 mm. from top of lips. Intestine pigmented. Nerve ring 0.2-0.29 mm. in male, 0.15 mm. in female from anterior end and at about mid-length of oesophagus; excretory pore just behind nerve ring.

Male—Spicules straight, narrow, 0.69-0.88 mm. long, 1:3.4 of body length, with wide striated alae ending a short distance from tips. Bursa large; lobes distinct, ventrals almost separated from each other. Ventral rays long, parallel, cleft for nearly whole length. Externo lateral diverging from lateral almost at its base and, like laterals, reaching almost to edge of bursa; externo-dorsal arising with laterals, but diverging widely, long, thin, not reaching edge. Dorsal ray dividing at about half length into two long thin branches nearly reaching edge of

bursa; each branch close to its origin giving off a lateral of about one-quarter its own length. Genital cone insignificant.

Female—Body narrowing beyond vulva to end in long pointed backwardly-directed tail. Uteri parallel; ovejectors stout; vagina quite short; vulva 0.38 mm., and anus 0.21 mm. from tip of tail. Large eggs in upper part of uterus but none seen in vagina or ovejectors of the only female available for study.

The species differs from all known representatives of the genus in regard to size and the characters of the dorsal ray.

***Cloacina similis* n. sp.**

Figs. 23-24

From the stomach of *Petrogale penicillata*, Upper Burnett River (coll. Dr. Bancroft). This species closely resembles *C. communis*, *C. magna*, and *C. petrogale* (hence specific name, *similis*) in the structure of the anterior end, but the female differs from that of the first two in the shape of the body, while the male has spicules with a relative length (spicule length: body length) nearer to that in *C. communis* than in the other two. The vagina is shorter than in any of these species, though the form of the tail and the relative positions of anus and vulva are similar in all. Male 8.1-8.2 mm.; female 7.1 mm. long. Oesophagus 0.84-0.9 mm.; 1:8.9-5 of body length. Nerve cord at 0.3 mm., excretory pore 0.8-0.83 mm., and cervical papillae at 0.07-0.08 mm. from anterior end.

Male—Bursa with well marked lobes, ventrals separate, dorsal bilobed. Ventral rays parallel, reaching edge of bursa; externo-laterals short; laterals cleft for most of length, not reaching edge of bursa; externo-dorsals arising with laterals and of similar length but divergent. Dorsal ray bifurcating after about one-third length, each branch bifurcating after half its length, the two final branches not reaching edge of bursa. Pair of prebursal papillae about 0.5 mm. from upper edge of bursa. Spicules long, 1.85-2.15 mm. (1:4.4-3.7 of body length), with striated alae and simple points.

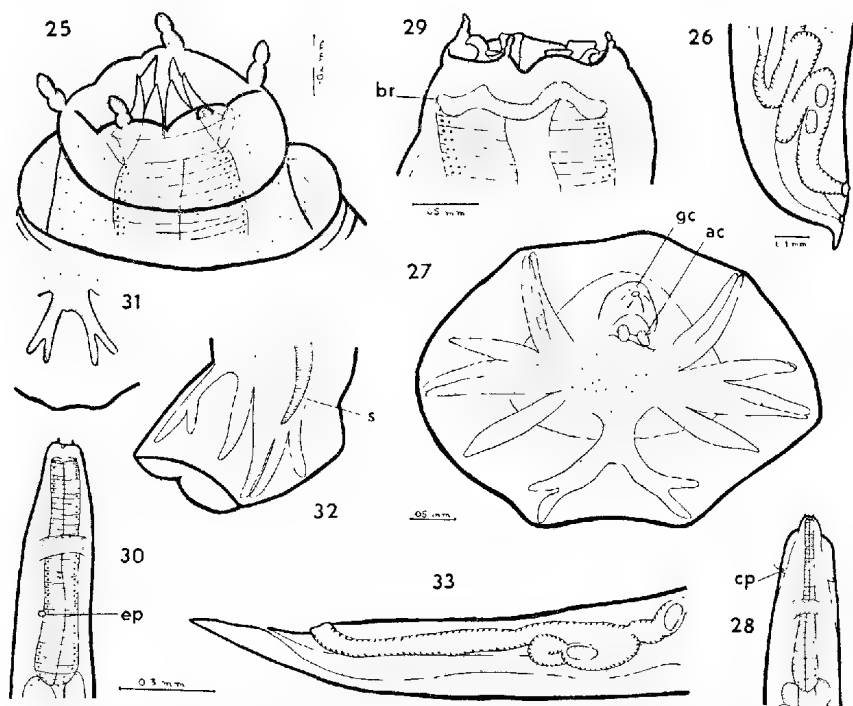
Female—Posterior end narrowing suddenly to end in conical tail, 0.14 mm. long; vulva 0.17 mm. in front of anus; latter 0.14 mm. from tip of tail; vagina about 0.5 mm. long; eggs 0.14 by 0.08 mm.

***Cloacina longispiculata* n. sp.**

Figs. 25-28

From *Macropus agilis*, Gregory River district, Carpentaria (coll. Dr. Roberts). Very stout worms, tapering rapidly at anterior end, but extremely little posteriorly; male 5.6-6 mm. long with maximum diameter 0.08 mm.; female 10-12 mm. long, 0.1 mm. broad. Cuticle inflated at anterior end, forming a cervical collar beginning 0.05 mm. from head end, where it projects 0.03 mm. from the body proper, and extending backwards for about 0.2 mm., gradually narrowing. Cervical papillae stout, passing through the inflated part of cuticle, 0.18 mm. from head end, and projecting as narrow filaments about 0.025 mm.

long. In many specimens the anterior end is damaged but a few show six low lips, with two-jointed papillae on the submedian and a small papilla on each lateral lip. Leaf crown prominent, arising from a narrow buccal ring, 0.03 mm. diameter and about 0.01 mm. in depth. Nerve ring at beginning of second half of oesophagus; the latter 0.52 mm. long, widening behind nerve ring. Excretory pore not observed.



Figs. 25-28, *Cloacina longispiculata*: 25, Head; 26, Posterior end of female; 27, Posterior view of bursa; 28, Anterior end. Figs. 29-33, *Cloacina bancroftorum*: 29, Head; 30, Anterior end; 31, Dorsal ray; 32, Lateral view of bursa; 33, Posterior end of female. Figs. 28, 30 and 33, to same scale; figs. 29, 31 and 32.

Male—Spicules exceedingly long; 3.5-3.7 mm. long, hence more than half body length; with wide alae. Bursa large; genital cone short; accessory cone of two small lobes. Ventral rays cleft to base; externo-lateral slightly shorter than medio- and postero-laterals which are cleft half-way and reach almost to edge of bursa; externo-dorsal arising with these latter and a little shorter; dorsal bifurcating about mid-length, each branch almost reaching bursal edge and giving off a short stout lateral ray near its end.

Female—Body tapering very suddenly beyond vulva to end in short pointed tail. Vagina long, wide, coiled. Vulva 0.37 and anus 0.17 mm. from tip of tail. Eggs (in vagina) 0.14 by .08 mm.

This species is characterised by the presence of the cervical collar and the very long spicules.

***Cloacina bancroftorum* n. sp.**

Figs 29-33

From stomach of *Macropus dorsalis*, Upper Burnett River (coll. Dr. Bancroft and Dr. J. M. Mackerras).

Short stout worms tapering markedly at head end. Males 4.5 mm.; females 4.2-5.8 mm. Six low lips; on top of each submedian a very small two-jointed papilla. Lips forming very wide circle around anterior end; within circle is leaf crown with each element wide and turned outwards at its distal end; mouth aperture correspondingly large. Buccal capsule shallow, chitinous walls uneven, with pronounced wavy outline. Oesophagus wide, straight, slightly wider at base, length in male 0.75 mm. (one-sixth body length), length in female 0.7-0.73 mm. (1:6-8 of body length); intestine very wide. Nerve ring 0.35 mm. from anterior end, lying at about mid-length of oesophagus. Excretory pore at 0.55-0.6 mm.; cervical papilla 0.09 mm. from head end.

Male—Spicules straight, short, 0.65 mm. (1:7 of body length), with wide striated alae. Genital cone short. Bursa lobes distinct, ventrals joined. Ventral rays long, parallel, cleft for almost whole length, extending nearly to edge of bursa; externo-laterals and laterals long, almost reaching edge; externo-dorsal not so long; dorsal ray soon dividing, each branch subdividing into two subequal branches, none reaching the edge of bursa.

Female—Body tapering gradually to end in a pointed tail. Uteri parallel; vagina long, rather narrow; vulva 0.48 mm., anus 0.25 mm. from tip of tail; eggs 0.11 by 0.04 mm.

The chief distinctive characters are the width of the buccal cavity, size of the papilla, shape of the chitinous wall of the buccal capsule and the length of the spicules. The specific name is given in recognition of the very valuable service rendered for many years by the late Dr. Bancroft and by his daughter, Dr. J. M. Mackerras.

CLOACINA COMMUNIS J. & M., 1938

Female specimens were obtained from *Macropus parryi*, Upper Dawson Valley (River Dec), collector Dr. Bancroft.

CLOACINA MACROPODIS J. & M., 1938

This species was represented amongst material taken by Dr. Roberts from *Macropus agilis*, Gregory River, North Queensland; and from *M. welsbyi*, Stradbroke Island.

CLOACINA sp.

Specimens of one or more species belonging to *Cloacina* were found amongst material taken from *Macropus apicalis* (Upper Mary River); *M. dorsalis* (Eidsvold); *M. welsbyi* (Stradbroke Island); *M. agilis* (Gregory River); and *Isoodon obesulus* Shaw (Eidsvold). Their state of preservation prevented further identification.

Genus PHARYNGOSTRONGYLUS Yorke and Maplestone, 1926

Syns. *Spirostrongylus* Mönnig, 1926; *Rugopharynx* Mönnig, 1926

The following diagnosis is based largely on that of Yorke and Maplestone: *Trichoneminae*—Body tapering gradually anteriorly, head directed straight forwards, mouth collar with six rounded papillae of which the two lateral may be larger than the four submedian. Cuticle smooth, with (in some cases) a few fine striations anteriorly. Buccal capsule short, cylindrical. Corona radiata, if present, arising from near the anterior end of the buccal capsule; external leaf crown may be present. Buccal capsule leading into a cylindrical vestibule of varying length, with heavily chitinated walls, which are striated in different directions in the different species, some circularly, some spirally, some radially. Oesophagus long, slender, usually divided into a wider anterior and a shorter narrower posterior region ending in a bulb. Cervical papillae long, thin. Excretory pore behind nerve ring.

Male—Bursa short, lobes distinctly separated; ventrals may be joined (type species) or separate. Inside surface of bursa usually with numerous papillae. Ventral ray cleft distally; externo-lateral, lateral and externo-dorsal arising together, laterals being longest; externo-lateral and externo-dorsal often lifting lateral wall of bursa. Dorsal ray divided for at least half its length, each long secondary stem giving off near its anterior end a short lateral branch. Spicules short and stout or long and thin; wide striated alae. Usually a prominent genital cone and an accessory cone. Gubernaculum may be present.

Female—Posterior extremity narrowing suddenly behind vulva to end in a long tapering tail. Uteri parallel; vulva a short distance in front of anus.

Parasites in the stomach of marsupials. Type species: *P. macropodis* Y. & M. Other species: *P. australis* (Mönnig, 1926); *P. brevis* Canavan, 1931; *P. woodwardi* Wood, 1930; *P. alpha* Johnston and Mawson, 1938 b; *P. beta* Johnston and Mawson, 1938 b.

Five new species are proposed in the present paper: *P. gamma*, from *Macropus dorsalis* and *M. parryi*; *P. delta*, from *M. dorsalis*; *P. epsilon*, from *M. dorsalis*; *P. zeta*, from *M. dorsalis*, *M. thetidis*, and *Petrogale penicillata*; *P. eta*, from *Macropus* sp. We also record the identification of specimens of *P. macropodis* Y. & M., from *Macropus parryi* and *M. major*; *P. brevis* Canavan, from *Macropus parryi*; and *P. alpha* J. and M. from *Petrogale penicillata*.

***Pharyngoststrongylus gamma* n. sp.**

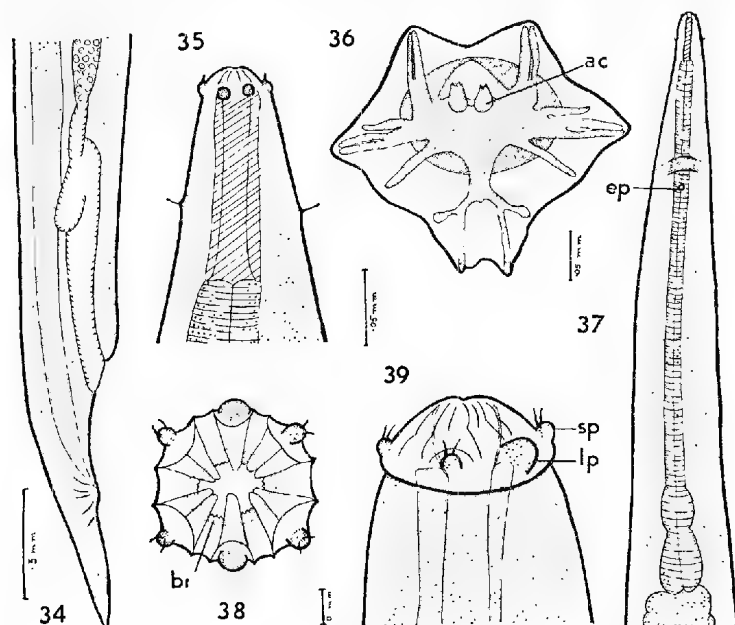
Figs. 34-39

From stomach of *Macropus dorsalis* (type host) and *M. parryi*, both from the Upper Burnett River (coll. Dr. Bancroft).

Thin; male 5.8-6.6 mm. long, shorter and relatively stouter than female 7.6-8.7 mm. long. Mouth collar with six papillae; the four submedians thinner, more prominent, and each with two bristles; laterals stout and squat. Rounded anterior end arising from within the collar and protected by an external leaf crown of

ten elements; the latter arranged so that two come up from the region of each submedian papilla, and one from each lateral papilla, the interpapillary areas being apparently unprotected. Around the base of each papilla is a non-chitinised area. Upper ends of elements curved inwardly. On looking down into the circular mouth, the anterior edge of the buccal capsule appears to consist of numerous minute pieces closely fitted together in a circle, the inner edges giving a serrated effect. This is probably the internal leaf crown.

Buccal capsule deep (0.013 mm.), with thin curved walls, probable internal leaf crown arising from upper edge. Vestibule or pharynx long, 0.11–0.13 mm., marked by prominent spiral striations arranged at 45° to long axis of organ. Cervical papillae long, thread-like, situated about 0.08–0.17 mm. from anterior end



Figs. 34–39, *Pharyngostromylis gamma*: 34, Posterior end of female; 35, Anterior end; 36, Bursa, posterior view; 37, oesophageal region; 38, Head, anterior view; 39, Head, sublateral view. Figs. 34 and 37 to same scale; figs. 38 and 39 to same scale.

and just behind level of mid-length of vestibule. Nerve cord about 0.4 mm., and excretory pore at 0.45–0.47 mm. from head end. Oesophagus thin, very long; 1.45 mm. in female (1.6 of body length); 1.42–1.49 mm. in male (1.3–1.4 of body length); posterior fifth widened, with constriction in its mid-region. Intestine wide, with short loop in its most anterior portion.

Male—Spicules narrow, 2.1 mm. long, 1.2–1.3 of body length, with striated alae. Bursa with well-marked lobes; dorsal with shallow median indentation; lateral longest. Ventral rays long, thin, extending almost to edge of bursa, cleft for about half their length; externo-lateral short, stout at base; laterals long, cleft for half their length reaching nearly to edge of bursa; externo-dorsal arising

separately, short, thin. Dorsal ray bifurcating about half length, each stem soon giving off a short club-shaped lateral branch before passing down to meet edge of bursa. Genital cone short, rounded; accessory genital processes rather long, with a bifid distal end.

Female—Body narrowing greatly just before vulva to end in long thin tail. Uteri parallel; vagina long; vulva 0.7 mm; and anus 0.45 mm. from posterior end, eggs small (0.04-0.05 by 0.06-0.08 mm.).

This species closely resembles *P. macropodis* but differs in regard to length, striations on vestibule, shape of buccal capsule, and shape of dorsal ray.

Pharyngostrongylus delta n. sp.

Figs. 40-43

From stomach of *Macropus dorsalis*, Upper Burnett River (coll. Dr. Bancroft).

These very small worms are recognisable at a glance by the shape of the vestibule, which is about twice as long as broad; the lumen is long and narrow, and the chitinous wall is constricted at the top and bottom as well as at one-third and two-thirds of its length, so that there appear to be three parts to the vestibule. Of these the first has, in optical section, the form of a trapezium with its base at the posterior end, while the second and third sections are barrel-like. Male 4.47-6.5 mm. long; female about 5 mm. Six small papillae around anterior end, but not adjacent to the small circular mouth. No distinct leaf crown, but inner edge of buccal capsule divided into 12-16 semi-detached sections. Buccal capsule about 5 μ deep. Vestibule 0.03-0.04 mm. long with circular striations. Oesophagus 5.5-6.4 mm. long in male (1:8-10 of body length), 0.6-0.65 mm. in female (1:8 of body length); wider anterior portion (0.4 mm. in male) followed by narrower part ending in a bulbous enlargement. Nerve cord at 0.4-0.43 mm., and excretory pore at 0.45 mm. from anterior end. Cervical papillae thread-like, 0.07 mm. from head end and just behind vestibule.

Male—Spicules quite short, 0.52-1 mm. long (1:6.5-8.6 of body length); rather stout with very wide striated alae and rather thick blunt tips. Internal surface of bursa covered with conical papillae, especially numerous and large on lower edge and on lateral lobes. Lateral lobes long, wide; ventrals short, small, not joined ventrally. Rays difficult to distinguish; externo-lateral lifting lateral wall; externo-dorsal long, stout; dorsal very stout, at about mid-length giving off two short stout lateral processes; and ending in a very short median piece and two long stems reaching almost to bursal edge.

Female—Body narrowing at about level of vulva and more suddenly behind anus to end in long thin pointed tail. Ovejectors short; vagina wide, short; vulva 0.27-0.3 mm., and anus 0.22-0.25 mm. from posterior end.

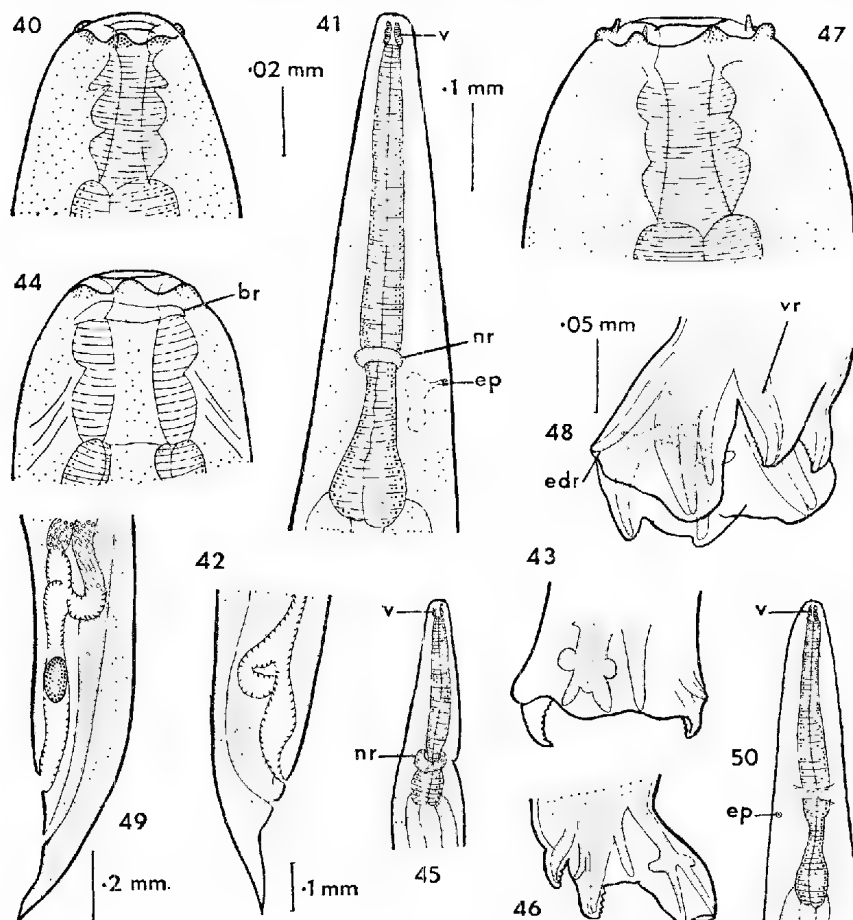
The species is differentiated from all other known members of the genus by the form of the vestibule and dorsal ray, though the shape of the vestibule is somewhat like that of *P. zeta*.

Pharyngostrongylus epsilon n. sp.

Figs. 44-46

From stomach of *Macropus dorsalis* (type host) and *M. wilcoxi* Eidsvold (coll. Dr. Bancroft).

Small thin worms resembling *P. delta* but possessing only two subdivisions of the vestibule. Male 4.2-5.3 mm. long, 0.28 mm. broad; female not seen. Six small papillae on mouth collar. Buccal capsule 4 μ deep, lined by thin cuticle.



Figs. 40-43, *Pharyngostrongylus delta*: 40, Head; 41, Oesophageal region, lateral view; 42, Posterior end of female; 43, Outline of bursa showing dorsal ray. Figs. 44-46 *Pharyngostrongylus epsilon*: 44, Head; 45, Oesophageal region; 46, Bursa, dorso lateral view. Figs. 47-50, *Pharyngostrongylus zeta*: 47, Head; 48, Lateral view of bursa; 49, Posterior end of female; 50, Oesophageal region. Figs. 40, 44 and 47 to same scale; figs. 43, 45 and 48; figs. 45, 49 and 50.

Vestibule 0.035-0.045 mm. long, 0.01 mm. inside diameter; apparently radially striated; walls about 0.01 mm. thick except in its mid-region, where there is a constriction subdividing the vestibule; inner walls slightly convex in section.

Oesophagus 0.54-0.6 mm. long, 1:7-10 of body length, shorter than in most species of genus, anterior widened portion about live-sevenths of length and narrowing very suddenly to become surrounded by nerve ring; behind the latter is the bulb. Excretory pore at 0.4 mm., and nerve ring at 0.45 mm. from anterior end.

Male—Bursa large, papillate; ventral lobes small, separate; lateral lobes larger; dorsal lobe very long with short median indentation. Ventral rays together, parallel; externo-lateral short, but reaching edge of bursa; laterals long, parallel, extending to edge of longest part of lateral lobe, cleft nearly all their length; externo-dorsal arising with laterals and about same length as externo lateral but not reaching edge of bursa. Dorsal ray stout, bifurcating after half its length, at which point two short lateral branches are given off. Spicules 0.85 mm. long, 1:5-6.2 of body length.

The species resembles *P. delta* but differs in the length of spicules and in the form of the oesophagus and vestibule.

***Pharyngostromylus zeta* n. sp.**

Figs. 47-50

From *Petrogale penicillata*, type host, Upper Burnett River (coll. Dr. Bancroft); *Macropus dorsalis*, Brisbane Botanical Gardens; and *M. thetidis*, Eidsvold (Dr. Bancroft).

Short, thin, tapering towards each end. Male 7.7-2 mm. long; female 7.8-2 mm. Anterior end with six small papillae, two lateral and four submedian, the latter each with short forwardly-directed process. Vestibule about 0.04 mm. long, 0.013 mm. inside diameter, commencing at 0.019 mm. from head end; with walls 7 μ average thickness, circularly striated, constricted by two rings so as to appear trilobed in optical section. Oesophagus thin, 0.72-0.75 mm. long in male (1:7.7-10 of body length); 0.8-0.82 mm. in female (1:8.7-10 of body length); anterior tubular portion about three-fifths of total length and surrounded near posterior end by nerve ring, then gradually narrowing to widen into the posterior bulb. Nerve ring at 0.4-0.5 mm., and excretory pore at 0.5-0.6 mm. behind head end. Cervical papillae thread-like, at 0.14-0.15 from anterior end.

Male—Spicules rather long, 1.6-1.62 mm., 1:4.2-4.4 of body length, slender, with striated alae, points separate. Bursa large, lobes separated by deep clefts and covered on internal surface by numerous papillae—especially the lateral lobes; ventral lobes small, separate. Ventral rays parallel, reaching edge of bursa; externo lateral short, parallel to laterals; laterals longer than externo-lateral and cleft for nearly whole length; externo-dorsal arising with laterals and a little longer than externo-lateral and lifting lateral wall of bursa. Dorsal ray stout, soon bifurcating, each branch passing laterally and posteriorly, continuing nearly to edge of deeply indented bursa, each branch giving off after about one-third its length a short lateral ray. Genital cone rather long; accessory cone present.

Female—Body tapering from region of vulva to end in long pointed tail. Uteri parallel; ovejectors about 0.3 mm. long; vagina rather long (about

0.75 mm.); vulva 0.37-0.4 mm. in front of anus; anus 0.25 mm. from tip of tail; eggs 0.12 by 0.06 mm.

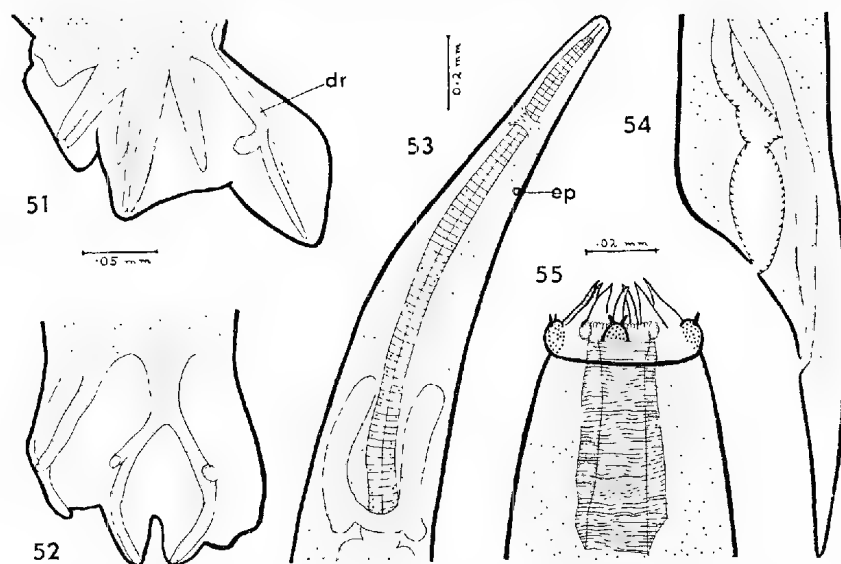
This species has a vestibule with characters intermediate between those of *P. delta* and *P. alpha*, but differs from both in the position of the nerve ring and excretory pore, length of spicules, and shape of vagina.

***Pharyngostromylus eta* n. sp.**

Figs. 51-55

From stomach of *Macropus* sp. from Millmerran, Darling Downs (Dr. Roberts).

Stout worms; males 8.5-11 mm. long; females 10.7-11.1 mm.; body tapering, especially towards anterior end; usually curved, especially at posterior end. Head very like that of *P. gamma*, differing mainly in having all six papillae of equal



Figs. 51-55. *Pharyngostromylus eta*: 51, Bursa, lateral view; 52, Bursa, dorsal view; 53, Anterior end; 54, Posterior end of female; 55, Head of female. Figs. 51 and 52 to same scale; figs. 53 and 54.

size, and all bearing two short bristles; internal leaf crown similar; buccal capsule of about the same shape, its anterior edge with numerous small pieces, probably elements of a short internal leaf crown. Buccal capsule 0.026 mm. in internal diameter and 0.01 mm. long. Vestibule 0.06 mm. long, 0.027 mm. internal diameter; walls stout, but narrowing suddenly at their base; walls with annular wavy striations 8.3μ apart.

Oesophagus long, thin, narrow, terminating after 1.35 mm. without any bulbar swelling; posterior end surrounded by dorsal and ventral prolongations of granular walls of intestine. Such lobes have been noted in many genera of *Trichoneminae* but are not so long as in the present species. Nerve cord at 0.35 mm., excretory pore at 0.51 mm. from anterior end. Cervical papillae not observed.

Male—Spicules 1.3-1.4 mm. long, 1:6-8.5 of body length; genital cone short; inside of bursa (especially lateral lobes) covered with papillae. Ventral rays short, parallel, cleft for half length; externo-lateral parallel to laterals and half their length; laterals extending nearly to edge of bursa, parallel, cleft nearly all their length; externo-dorsal long, arising separately. Dorsal ray longest of all; after one-third length dividing into two branches arranged like calipers, each branch reaching edge of dorsal lobe; latter divided by deep indentation; short lateral ray arising from each branch at about one-third of its length.

Female—Body slightly swollen ventrally in front of vulva and narrowing suddenly behind it to end in long tapering tail. Ovejectors long, narrow; vagina short, wide; vulva about 0.31 mm. in front of anus; anus 0.5 mm. from tip of tail; in some specimens tail directed dorsally. Eggs in uterus about 0.04 mm. by .1 mm.

The species possesses features suggesting those of *P. gamma* and *P. macropodis*. From the former it differs in its greater length, relatively shorter spicules, absence of accessory genital cone, relatively shorter vestibule with horizontal striations. It differs from *P. macropodis* in its shorter length, different head papillae and shorter vestibule.

PHARYNGOSTRONGYLUS MACROPODIS Y. and M.

We have identified this species from *Macropus major*, Dee River, Upper Dawson Valley (Dr. Bancroft); and from *M. parryi*, Upper Burnett River (Dr. Bancroft).

PHARYNGOSTRONGYLUS BREVIS Canavan

Obtained from *Macropus parryi*, Upper Burnett River (Dr. Bancroft).

PHARYNGOSTRONGYLUS ALPHA Johnston and Mawson

This species was obtained from a rock wallaby, *Petrogale penicillata*, Upper Burnett River (Dr. Bancroft).

Buccostrongylus new genus

Trichoneminae—Characterised by very long buccal capsule, whose anterior edge may be prolonged into four or six tooth-like projections. No leaf crown; six to eight lips, more or less developed, and behind these are six papillae, four submedian and two lateral, each submedian bearing a thread-like appendage. Buccal capsule twice to three times as long as wide. Oesophagus long, slender, ending in a small but distinct bulb. Intestine pigmented. Bursa small, ventral lobes very small. Externo-dorsal ray arising separately from laterals which are close together. Dorsal ray after one-third of its length dividing into two long branches forming an arch and reaching the bursal edge; at point of bifurcation, two small lateral rays are given off. Female characterised by long thin backwardly directed tail; parallel uteri; short ovejectors; long, thin vagina; and large thick-shelled eggs. Parasites in stomach of marsupials—Type species *B. buccalis*, from *Macropus dorsalis*. Other species *B. australis* n. sp., from *M. wilcoxi*.

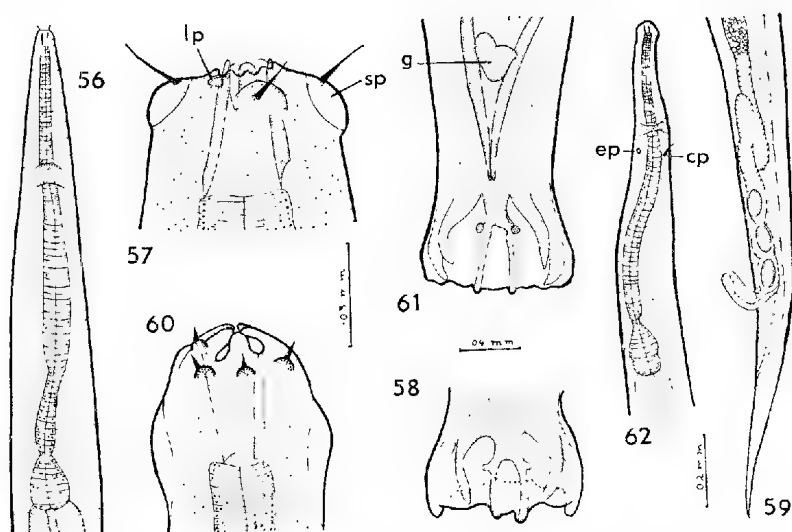
This new genus is near *Pharyngostrongylus* but differs from it in the absence of a striated vestibule and in the presence of a very long buccal capsule, the latter suggesting that of *Cylindropharynx*.

***Buccostrongylus buccalis* n. sp.**

Figs. 56-59

From stomach of *Macropus dorsalis* (type host), *M. wilcoxi* and *M. parryi* all from the Upper Burnett district (coll. Dr. Bancroft).

Small worms; male 3.72-5.3 mm. long; female 4.5 mm. At anterior end four large cuticular papillae in submedian positions, each with long hair-like appendage, 0.026 mm. long; two smaller lateral papillae. Around oral aperture



Figs. 56-59. *Buccostrongylus buccalis*: 56, Anterior end; 57, Head; 58, Dorsal view of bursa; 59, Posterior end of female. Figs. 60-62, *Buccostrongylus australis*: 60, Head; 61, Posterior end of male, dorsal view; 62, Anterior end. Figs. 56, 59, and 62 to same scale; figs. 57 and 60; figs. 58 and 61.

about eight small lobes. Buccal capsule cylindrical, long, (0.02-0.033 mm.), thin walled, without striations; posterior edge of wall thin, pointed; anterior border apparently prolonged into four structures resembling elements of a leaf crown. Oesophagus thin, long, 1.36-1.4 mm. (1:2.7-3.7 of body length in male); in female anterior cylindrical part 0.9 mm. long, widened posteriorly, surrounded near mid-length by nerve ring, and followed by narrower region (0.2 mm. long) constricted at its lower end to be succeeded by bulb about 0.15 mm. long. Intestine wide and thick-walled in anterior region. Nerve ring at 0.3 mm. from head end. Excretory pore and cervical papillae not observed.

Male—Spicules 1.56-1.67 mm. long, 1:2.4-3.1 of body length, rather stout, especially at tips which do not taper but end in a conical point; alae striated, wide, ending just before tip. Bursa small, lateral lobes the most prominent. Ventral rays parallel, reaching almost to bursal edge; externo-lateral rather shorter than laterals; laterals cleft for half their length, reaching nearly to edge of bursa. Externo-dorsal arising independently, reaching nearly to edge. Dorsal ray bifurcating after one quarter of length, each branch soon giving off a very short lateral ray and then passing backwards into a small projection of the dorsal lobe. Genital cone very short.

Female—Tail long, narrow, pointed, bending backwards from the vulva; vagina extended through the vulva to a greater or lesser extent in all females examined. Vulva at 0.7, and anus at 0.5 mm. from tip of tail; eggs (in vagina) 0.07 mm. by .05 mm.

***Buccostrongylus australis* n. sp.**

Figs. 60-62

From stomach of *Macropus wilcoxi* (type host) and *M. thetidis*, Eidsvold (coll. Dr. Bancroft).

Very small; male 4.5-4.7 mm. long; female 5.5-6.8 mm.; thin, body tapering towards head, latter surrounded by ring of inflated cuticle; body dark owing to pigment in intestine. Anterior end not clear in any of the numerous specimens examined; buccal capsule long (0.22-0.25 mm. long, 16 μ wide at top, 13 μ at base) with rather thick walls, anterior margin apparently simple, mouth with six lips more prominent than those of *B. buccalis*; papillae all of same size, each with stout bristle. Oesophagus long, 0.82-1 mm. in male (1:4.7-5.4 of body length), 1-1.17 mm. in female (1:5.5-8 of body length), slightly constricted near posterior end before widening into bulb, latter generally with slight constriction in its mid-region. Nerve ring at 0.27-0.29 mm., excretory pore at 0.36 mm. behind head end. Cervical papillae very long, hair-like, situated at 0.37-0.4 mm. from anterior end.

Male—Bursa very small; ventral lobes very small, separate. Ventral rays parallel, cleft for about half length; externo-laterals and laterals arising together, short, stout; laterals longest, cleft for most of length. Externo-dorsal long, stout, arising separately, curving towards dorsal ray, not reaching bursal edge. Dorsal ray subdividing at about one third length; the two branches well separated, more or less parallel, long; each branch giving off very short lateral soon after origin from main stem. Spicules long, 1.2-1.37 mm., 1:3.4-3.7 of body length, slender, with wide striated alae and tapering joined tips. Gubernaculum heart-shaped in dorso-ventral view, but wider anteriorly and pointed posteriorly when seen in lateral view. Genital cone insignificant.

Female—Posterior end drawn out into long tapering, but not sharply pointed, tail. Ovejectors short; vagina long; vulva 0.8-0.9 mm., and anus 0.45-0.55 mm. from posterior end. Eggs 0.09 by .04 mm.

This species is distinguished from *B. buccalis* by its shorter buccal capsule; longer lips; shorter stouter bristles on the papillae; relatively shorter, differently

shaped, oesophagus; shorter spicules; longer tail region of the female; and in having the anterior end of buccal capsule apparently without small projections.

MACROPOSTRONGYLUS Yorke and Maplestone, 1926

MACROPOSTRONGYLUS YORKEI Baylis, 1927

We have recognised this species from *Macropus agilis* (Gregory River, North Queensland, coll. Dr. Roberts), *M. parryi* (Upper Burnett region, coll. Dr. Bancroft), and *M. zvelsbyi* (Stradbroke Island, South Queensland). Baylis found it in material from *Macropus* sp. (1927) from Townsville and from *Macropus agilis* from Burketown (1934).

MACROPOSTRONGYLUS MACROPOSTRONGYLUS Y. and M., 1926

We record the occurrence of the type species of the genus in *M. agilis* from Gregory River, North Queensland (coll. Dr. Roberts), and *Macropus zvelsbyi* from Stradbroke Island.

Papillostrongylus new genus

Trichoneminae—Mouth directed straight forwards. Mouth collar with eight papillae; four submedian bearing bristles; dorsal and ventral papillae small, rather chitinated and projecting (in lateral view) like a blunt hook; two laterals appearing tridentate in ventral view. Buccal capsule large, bilaterally symmetrical; the dorsal and ventral walls sloping down and inwards in a straight line, lateral walls being concave inwardly and convex outwardly. Oesophagus relatively long, terminating in a slight bulb.

Male—Bursa small; ventral lobes short, separate; dorsal lobe large. Ventral rays parallel and together; externo-lateral, lateral and externo-dorsal rays arising together; laterals parallel and long; dorsal bifurcating, each stem with a short lateral branch. Spicules thin, long, simple.

Female—Uteri parallel; vagina fairly long; vulva a short distance in front of anus; tail tapering, pointed.

Type *P. labiatus* n. sp. from stomach of *Macropus dorsalis*. The genus is close to *Macrostrongylus* but is differentiated from it by the shape of the buccal capsule, the absence of a leaf crown and the presence of eight distinctive papillae around the mouth. This genus is distinguished from *Cloacina* by the shape of the vestibule; the number and shape of the head papillae; and the absence of a corona radiata.

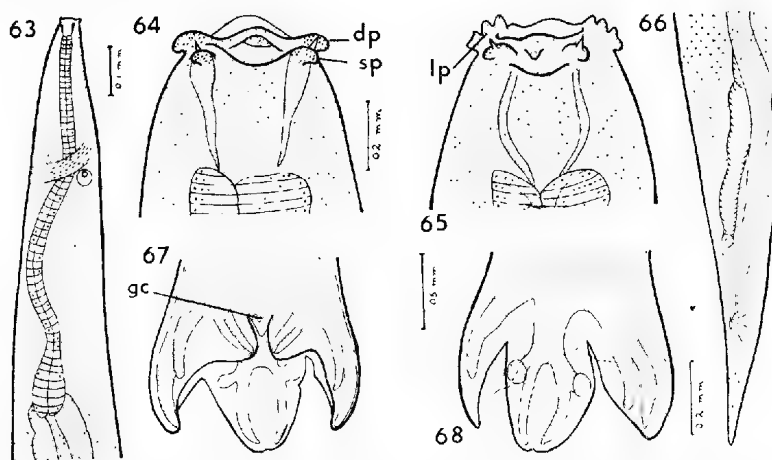
Papillostrongylus labiatus n. sp.

Figs. 63-68

From the stomach of *Macropus dorsalis* Eidsvold (Dr. M. J. Mackerras). Only a male and a female specimen, both juvenile, were found.

Short, thin; male 4.7 mm. long; female 7 mm.; maximum breadth of male 0.28 mm. Eight head papillae; the four submedian each projecting outwards and bearing short anteriorly-directed bristle; dorsal and ventral papillae more chitinated

than the others and in lateral view projecting outwards and downwards like a thick blunt hook; lateral papillae large, simple, tridentate (fig. 65). Buccal capsule 0.036 mm. long, chitinated; walls in lateral view nearly straight, thickest anteriorly, closer together posteriorly, but in ventral view appearing to have uniform thickness and each side with concavity inwardly. No leaf crown. Oesophagus very long, 0.65 mm. in male (1.7 of body length), 0.83 in female (1.8 of body length), with very slight posterior bulb. Nerve ring at 0.3 mm. from head end of female and just behind level of first third of oesophagus; excretory pore at 0.33 mm., just behind nerve ring; cervical papillae at 0.09 mm. from anterior end (female).



Figs. 63-68. *Papillostrongylus labiatus*: 63, Anterior end; 64, Lateral view of head; 65, Dorsal view of head; 66, Posterior end of female; 67, Ventral view of bursa; 68, Dorsal view of bursa. Figs. 64 and 65 to same scale; figs. 67 and 68.

Male—Bursa small; ventral lobes small, separate; laterals long; dorsal lobe longer. Ventral rays parallel, cleft for nearly all length, reaching bursal edge; externo laterals short; laterals long; externo-dorsal arising from same root and as long as externo-lateral. Dorsal ray stout, bifurcating at mid-length, each branch almost reaching edge, and giving off short lateral just beyond region of bifurcation. Genital cone short; accessory cone with two bilobed projections. Spicules relatively very long, 2 mm. (1.2.35 of body length), thin, curved within body, ending in separate points.

Female—Body tapering beyond vaginal region to end in bluntly pointed tail; uteri parallel; vagina about 0.4 mm. long; vulva at 0.38, and anus at 0.34 mm. from posterior end.

***Coronostrongylus* n. gen.**

Trichoneminae.—Short worms; buccal cavity lined by thick continuation of cuticle, and reinforced around its lower part by stout buccal ring. Leaf crown of 20-25 elements; six papillae around mouth. Oesophagus with longer anterior

portion and shorter posterior part ending in bulb. Characters of male insufficiently known. From marsupials. Type, *C. coronatus* n. sp. It differs from other genera in the character of the buccal capsule and in the presence of numerous clements in the leaf crown.

***Coronostrongylus coronatus* n. sp.**

Fig. 69

Only two specimens of this species have been found, a male in the stomach of *Macropus wilcoxi* (type host) and a female in the stomach of *M. thetidis*, both from Eidsvold (Dr. Bancroft). Both worms were greatly wrinkled, as if the

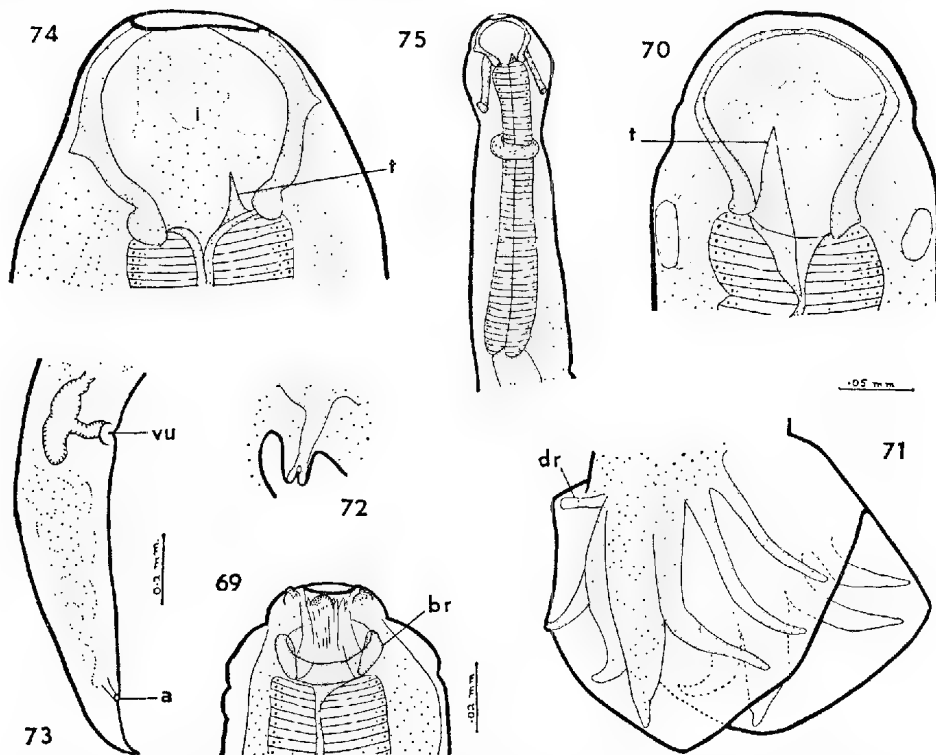


Fig. 69, *Coronostrongylus coronatus*: Lateral view of head. Figs. 70-73, *Globoccephaloides wallabiae*: 70, Lateral view of head; 71, Lateral view of bursa; 72, Dorsal ray; 73, Posterior end of female. Figs. 74-75, *Globoccephaloides affinis*: 74, Lateral view of head; 75, Anterior end, lateral view. Figs. 70, 71, 72 and 74 to same scale; figs. 73 and 75.

cuticle had been thrown into many circular folds by the contraction of the tissues beneath it. They appear (in this condition) as short stout nematodes, the male 2.85 mm. long, and the female 3.6 mm. long. A very stout chitinous ring, 0.014 mm. deep and .022 mm. in internal diameter surrounding base of buccal cavity, and from the base of this the inner lining of the buccal cavity rises up to become continuous with the cuticle around mouth. Leaf crown of numerous

(20-25) long thin elements rising from posterior circumference of buccal cavity but apparently distinct from, although parallel to, the chitin lining the cavity. Mouth circular, simple; surrounded by six rounded papillae, each with small rounded projection distally. Oesophagus bent, in the two specimens examined, but not the same way in each case, lending support to the view that the worms have shrunk; in male 0.47 mm. long, in female .48 mm.; 1:6-7 of body length, respectively; widening gradually for the first two-thirds of length, then suddenly narrowing and then widening to end in large bulb. In the female the long, hair-like cervical papillae are 0.15 mm., and the nerve ring 0.21 mm. from the anterior end.

Male—The bursa covered on inside with papillae. Arrangement of rays not traced satisfactorily, but dorsal ray appears to end in two long branches. Roundish gubernaculum present. Spicules 1.1 mm. long, 1:2.6 of body length. Specimen, unfortunately, lost before completion of its examination.

Female—The condition of the specimen prevented its adequate study. Body narrowing suddenly to form long thin tail, greatly wrinkled, probably because of shrinkage.

Genus GLOBOCEPHALOIDES Y. and M., 1926

The discovery of two new species of this genus, one of them represented by males and females, has made it possible to amplify Yorke and Maplestone's generic diagnosis, and to indicate its systematic relationships. The characters of the copulatory bursa, the presence of a well-defined sub-globular buccal capsule, the absence of a leaf crown or mouth collar, and the absence of cutting organs guarding the oral aperture, indicate a close relationship with *Globocephalus*, as was suggested by Yorke and Maplestone. It differs from this genus chiefly in the structure of the bursa; each of the ventral and lateral rays being separate from one another, the dorsal ray relatively shorter and its two branches not tridigitate. The position of the vagina is quite different in the two genera.

An amended definition of the genus is now offered: *Strongylinae*—Small worms, anterior extremity inclined dorsally, mouth opening circular, without corona radiata. Buccal capsule large, subglobular; duct of dorsal oesophageal gland not projecting into mouth cavity; a prominent triangular subventral tooth in base of capsule. Oesophagus slightly club-shaped posteriorly.

Male—Bursa prominent with two large lateral lobes and a much smaller dorsal lobe. All rays separate, nearly reaching edge of bursa; ventrals thinnest, medio-lateral stoutest and tapering suddenly; externo-dorsal arising at base of dorsal; dorsal ray bilid at tip. Spicules equal, alate, tapering to a fine point.

Female—Posterior end tapering regularly, ending in conical tail; vulva in posterior quarter of length; vagina short; uteri divergent; oviparous.

Parasites of alimentary tract of marsupials. Type species: *G. macropodis* Y. and M., 1926 (male unknown), from *Macropus* sp.

Freitas and Lent (1906) described *Globocephalus marsupialis* from a Brazilian polyprotodont, *Metachirus opossum* L., and placed *Globocephaloides* as a synonym of *Globocephalus*, an emended diagnosis of the latter being published. As already stated by us, we regard the two genera as quite distinct. The Brazilian species does not belong to the Australian genus.

***Globocephaloides wallabiae* n. sp.**

Figs. 70-73

From intestine of *Macropus dorsalis*, Eidsvold (Dr. Bancroft).

Very small worms; male 4.2 mm. long; female 4.4 mm. Anterior end rounded. Buccal capsule large, subglobular, 0.05 mm. wide, 0.055 mm. long, strongly chitinated, lower part of walls thicker than roofing portions, base with out-turned rim. Arising from subcuticular region just behind level of floor of buccal cavity are four strongly chitinated supports lying against walls of capsule for about half the length of the latter, these supports probably submedian in position. "Pulp" extending to front of head region as six (perhaps eight) long masses, but not piercing the cuticle to produce definite papillae; papillae not detected. Cuticular lining of buccal cavity continued into oesophagus and forming pointed subventral tooth projecting 0.025 mm. into buccal cavity. Oesophagus 0.52-0.55 mm. long (1:8 of body length); widening gradually posteriorly.

Male—Bursa large, consisting chiefly of two large lobes lying laterally and not subdivided into lateral and ventral lobes; dorsal lobe very short, narrow. Ventral rays long, thin, separate, curving ventrally; externo-lateral thin, long, curving laterally; two laterals separate, stout, with distal ends compressed; externo-dorsal thin, projecting on edge of bursa. Dorsal ray very short, narrow, bifurcate distally, its two branches extending each into a short lappet of the dorsal ray. Spicules short, 0.4 mm. long, 1:10 of body length, rather wide, distal two-thirds with curved outer edges; tips spoon-like.

Female—Body tapering beyond anus; sharp pointed tail curved ventrally; vulva at 0.95 mm. from tail end (*i.e.*, 1:4.6 of body length); uteri divergent; ovejectors short; anus at 0.2 mm. from end of body; eggs 0.095 by 0.055 mm.

The species differs from *G. macropodis* in its length, the size of the buccal capsule, length of oesophagus, position of vulva, and size of dorsal tooth. Yorke and Maplestone gave 400 μ as the depth of the buccal capsule and 900 μ as the length of the oesophagus, the former being apparently an error for 40 μ .

***Globocephaloides affinis* n. sp.**

Figs. 74-75

Three females were found amongst material from the intestine of *Macropus dorsalis* from Eidsvold (Dr. Bancroft). The species resembled closely *G. wallabiae* in general features. Length, 6.7 mm. Cuticle of head markedly inflated. Chitinous supports to buccal capsule arising more posteriorly than in the former

species. Capsule 0·13 mm. deep, 0·12 mm. wide. Oesophagus 0·85 mm. long, 1:8 of body length. Nerve cord probably at 0·25 mm. from head end. Vagina at 0·19 from tip of tail, *i.e.*, about 1:3·5 of body length. Eggs 0·1 by 0·045 mm.

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FURTHER NOTES ON THE AUSTRALIAN TROMBIDIIDAE WITH DESCRIPTION OF NEW SPECIES

By HERBERT WOMERSLEY, Entomologist, South Australian Museum

Summary

In the present paper a number of new species are described. In addition, however, the larvae of the genera *Chyseria* and *Caenothrombium* are for the first time recorded and described.

**FURTHER NOTES ON THE AUSTRALIAN TROMBIDIIDAE
WITH DESCRIPTION OF NEW SPECIES**

By HERBERT WOMERSLEY
Entomologist, South Australian Museum

[Read 13 July 1939]

In the present paper a number of new species are described. In addition, however, the larvae of the genera *Chyzeria* and *Cacnothrombium* are for the first time recorded and described.

The "itch mite" of the Coorong, South Australia, which has hitherto been regarded as the same species as that of Queensland, is now shown to be distinct and is described under the name of *Trombicula samboni* n. sp.

The considerable number of larval species described by Gunther (P. Linn. Soc. N.S.W., 64, 73-96, 1939) from New Guinea as *Neoschöngastia* is split up, the genus *Guntheria* being proposed for a unique form which also occurs in Queensland, and *Paraschöngastia* for four other species, the remainder being retained in *Neoschöngastia* s. str.

Four species and one variety of *Neoschöngastia* are described as new from Queensland. Keys to the Australian and New Guinea larval species of *Trombicula*, *Neoschöngastia* and *Schöngastia* are given.

My sincere thanks are tendered to Dr. E. H. Derrick and Mr. D. J. W. Smith, of the Laboratory of Microbiology, Brisbane, for the opportunity of examining their material; to Dr. C. E. Gunther, of New Guinea, and to other collectors mentioned, especially Mr. R. V. Southcott, who has been so successful in hatching the hitherto unknown larval forms of certain genera.

TROMBELLA Berlese, 1887

***Trombella adelaideae* n. sp.**

(Text fig. 1, A-D)

Description—General shape as in *T. warregense* Hirst. Length, 1.2 mm. Colour in life, white. Legs rather short, tarsus I rather parallel-sided 260μ by 90μ ; metatarsus 180μ . Crista absent. Pseudostigmal hairs fine and on small well-separated tubercles. Eyes 2 + 2, small, lateral and in line with the pseudostigmal hairs. Dorsum with six pits in each lateral row, and four in the centre row; all the pits are round except the anterior median. Dorsal setae as in *T. warregense*, but hardly or only indistinctly ciliated; these setae extend all over the surface of the pits, and do not form a double ring only around the margin as in *warregense*.

Locality—A single specimen from under a stone at Burnside, South Australia, 17th August, 1938. (J. S. W.)

Remarks—Closely related to *T. warregense* Hirst but differs in the dimensions of the front tarsi, the shape of the median dorsal pits and the clothing.

Genus MICROTROMBIDIUM Haller, 1882

Subgenus DROMEOTHROMBIUM Berlese, 1912

DROMEOTHROMBIUM MACROPODUS (Berl., 1903)

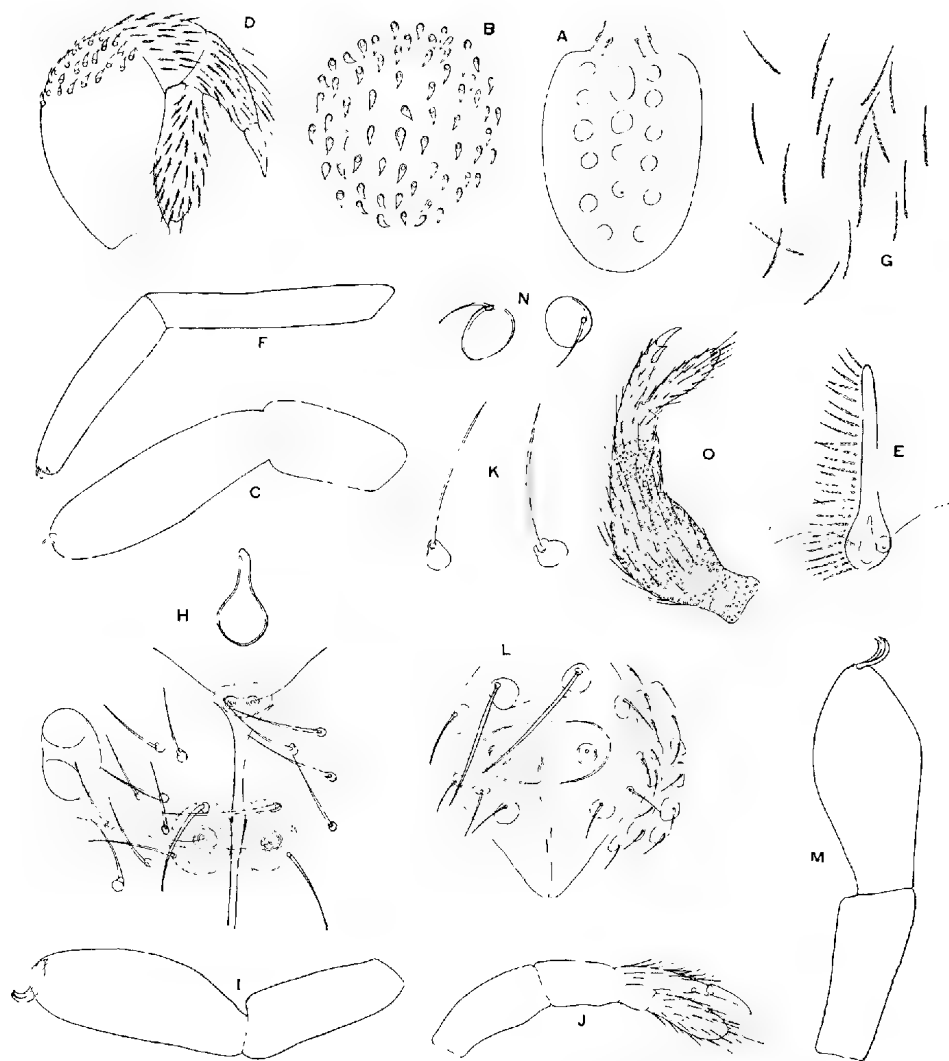
= *Trombidium macropodum* Berl., 1903. Redia 2, 155.*Microtrombidium (Dromcothrombium) macropodum* Berl., 1905, Redia 8, 132; Vitzthum, 1926, Treubia 8, 136.

Fig. 1 A-D—*Trombella adelaideae* n.sp.: A, dorsal view showing pits; B, arrangement of seta of a dorsal pit; C, front tarsus and metatarsus; D, palp. E-G—*Dromeothrombium dromus* n.sp.: E, crista; F, front tarsus and metatarsus; G, dorsal setae. H-K—*Johnstoniana vitzthumi* n.sp.: H, crista, nasus and left pair of eyes; I, front tarsus and metatarsus; J, palp; K, two dorsal setae; L-O—*Crossothrombium parkhousei* n.g., n.sp.: L, dorsal sensillary area; M, front tarsus and metatarsus; N, two of dorsal setae; O, palp.

Two specimens of this species, the type of the subgenus, have recently been collected by Dr. W. G. Heaslip in Queensland; one from Cairns, March, 1939, and one from Innisfail, December, 1939. Both specimens agree with the descriptions and figures given by Berlese and Vitzthum. The type specimen in the Hamburg Museum was from Buitenzorg, Java.

Dromeothrombium dromus n. sp.

(Text fig. 1, E-G)

Description—Colour creamy-white. Length to 2.4 mm., width to 1.3 mm. Legs I and IV much longer than body, I 3.32 mm., II 1.0 mm., III 1.8 mm., IV 2.7 mm.; tarsus I 600 μ long by 120 μ wide, parallel-sided, metatarsus 650 μ long; claws small. Crista as figured, 280 μ long with posterior sensillary area 78 μ wide furnished with a pair of fine sensillary hairs. Eyes absent. Palpi long, 460 μ , and slender, tibia with apical claw and accessory claw but no particularly strong outer dorsal spines; tarsus elongate and over-reaching tip of claw.

Dorsal setae as figured, mostly 40 μ long but with a sprinkling of longer ones of 80 μ . Body with fairly prominent shoulders.

Locality—Some half dozen specimens from under stones, associated with ants at Long Gully, South Australia, 18th August, 1938 (H. W.); another specimen from under stone, Murray Bridge, South Australia, 25th May, 1938 (R. V. S.).

Remarks—Close to *M. (D.) attolus* (Banks, 1916), but differs in size, dimensions of tarsus I and in the uniform shorter hairs (in *attolus* 1.2 mm., 310 μ by 69 μ and 21 μ , respectively).

JOHNSTONIANA George, 1909

= *Diplothrombium* Berl., 1910.

Johnstoniana vitzthumi n. sp.

(Text fig. 1, H-K)

Description—Length 2.0 mm. Colour reddish. Leg I and IV rather longer than body, I 2.0 mm., II 1.4 mm., III 1.5 mm., IV 2.7 mm.; tarsus I 400 μ by 150 μ , metatarsus 330 μ . Crista 250 μ long with two sensillary areas, one at anterior end, and one at one-third from posterior end; each furnished with two sensillary hairs, the posterior area consisting of two large circular areas one on each side of the mid-line, and besides the sensillary hairs carrying two strong setae. Eyes 2 + 2, on shields. In front of the crista is a strongly chitinated flask-shaped nasus; palpi slender, tibia with a strong claw with a smaller basal accessory claw, dorsally without any specially strong spines, tarsus slightly clavate, almost reaching tip of claw. Dorsal setae numerous, of long 50 μ , curved sharp setae arising from small tubercles.

Locality—A single specimen collected by Mr. Parkhouse at Second Valley, South Australia, during a visit by the Tate Society of the Adelaide University, December, 1938.

Remarks—This interesting species differs from the only other South Australian species of the genus, *J. australiense* (Hirst, 1928), in that the two sensillary areas of the crista are widely separated, the anterior being at the front end of the crista.

Genus **Crossothrombium** n. g.

Allied to *Johnstoniana* and probably more so to *Centrotrombium* Kramer in having only a single sensillary area and a single pair of sensillary setae. Crista practically absent. Eyes absent. Dorsal setae of the type of *Johnstoniana*, but arising from large pits or circles. Legs and palpi strongly chitinated and pitted. Tarsus of palp without terminal spines.

Genotype—*Crossothrombium parkhousei* n. sp.

Crossothrombium parkhousei n. sp.

(Text fig. 1, L-M)

Description—Length to 1.5 mm., width 1.0 mm. Colour in life reddish. Mouth parts and legs heavily chitinated. Legs rather short and stout, I 1.5 mm., II 1.2 mm., III 1.3 mm., IV 1.7 mm. Eyes absent. Palpi stoutish; tibia with strong apical claw and small basal accessory claw, and 2-3 strong dorsal spines, tarsus barely clavate and reaching tip of claw. Crista as figured with a single large transverse sensillary area and two sensillary hairs (lost in specimen), the whole on a cordate area with four pairs of setae, the anterior of which are long and strong. Tarsus I $380\ \mu$ by $180\ \mu$ as figured, metatarsus $300\ \mu$. Cuticle strong and closely covered with large roundish pits, from each of which arises a fine curved seta as long as the diameter of pits. Legs, palpi and capitulum strongly and closely covered with small depressions, and very finely punctate.

Locality—A single specimen collected by Mr. Parkhouse, after whom it is named, at Second Valley, South Australia, during a visit by the Tate Society of the Adelaide University, December, 1938.

Remarks—The affinities of this interesting form have been discussed under the genus.

TROMBICULA Berlese, 1905

TROMBICULA MINOR Berlese, 1904

Trombicula minor Berl., 1904, *Acari nuovi*, manip. IV, 155.

„ *hirsti* Sambon, 1927, *Ann. Mag. Nat. Hist.*, 20 (9), 157; nec.
Hirst, 1929, *Ann. Mag. Nat. Hist.*, 3 (10), 564; nec.
Womersley, 1934, *Rec. S. Aust. Mus.*, 5 (2), 212.

„ *hirsti* v. *buloloensis* Gunther, 1939. *Proc. Linn. Soc. N.S.W.*,
64, 78.

Gunther, by breeding the nymphal form from the larvae, has recently established⁽¹⁾ the identity of his *hirsti* v. *buloloensis* with *T. minor* described from Java

⁽¹⁾ Dr. Gunther has kindly allowed the nymphs to be deposited in the South Australian Museum. His paper on the nymphal stage appeared in the *Trans. Linn. Soc. N.S.W.*, published 15th Dec., 1939.

by Berlese. I have now received from Dr. W. G. Heaslip an adult female found at Innisfail in Queensland (December, 1939), which also corresponds to Berlese's species. As the only larval *Trombicula* known from Queensland is *T. hirsti* Sambon (the common itch-mite of that State), the above correlation is further confirmed.

The differences between typical *T. hirsti* and *T. hirsti* v. *buloloensis*, which are only those of hair lengths and size of scutum, would seem therefore to be of no value.

***Trombicula samboni* n. sp.**

= *T. hirsti* Hirst, 1929, nec Sambon, 1927; Womersley, 1934, nec Sambon, 1927.
(Text fig. 2, A-H)

Although it has for long been suspected that the "itch-mite" of South Australia might not be identical with the form described by Sambon from Queensland, it has only recently been possible to compare our local form with the type of *T. hirsti* from Queensland. Through the generosity of Mr. F. H. Taylor, of the School of Tropical Health, Sydney, I have been afforded the opportunity of examining a type slide of Sambon's species, and can now definitely state that the South Australian form is distinct, and take this opportunity of describing it as new.

Description—Length $260\ \mu$ by $156\ \mu$. Dorsal scutum $91\ \mu$ at widest between postero-lateral hairs, length $65\ \mu$, posterior margin evenly rounded, anterior margin slightly concave; anterior median and lateral hairs $39\ \mu$, posterior lateral hairs $47\ \mu$, sensory hairs placed slightly in advance of postero-lateral hairs, $65\ \mu$ long, sparsely ciliated on distal two-thirds; scutal surface finely pitted. Eyes $2+2$, small and distinctly separated from scutum. Palpi and mandibles as figured. Leg I with outer stout simple spine at one-third from base. Dorsal setae long and ciliated as figured, $39\ \mu$, arranged 2, 6, 6, 6, 4, 2.

Remarks—Differs from *T. hirsti* Sambon in the form of the dorsal scutum and the arrangement of setae on dorsum.

Locality—Common in the ti-tree scrub along the Coorong, South Australia.

KEY TO THE AUSTRALIAN AND NEW GUINEA SPECIES OF *TROMBICULA*

1. Dorsal setae more than 50. 2
Dorsal setae 42 or fewer. 3
2. Dorsal setae arranged 2, 14, 12, 4, 6, 8, 10, 8, 4, the posterior rows close set and their individual setae thicker and more strongly ciliated than the others. Dorsal scutum with the posterior margin convex laterally and concave medially; AW $118\ \mu$, PW $120\ \mu$, L $69\ \mu$. 2
T. rioi Gunther, 1939.
Dorsal setae 2, 6, 8, and then about 5 rows of 8 closely placed setae ciliated similarly to the others. Dorsal scutum with posterior margin evenly convex, AW $80\ \mu$, PW $86\ \mu$, L $51\ \mu$. 3
T. macropus Wom., 1936.
3. Dorsal setae 42, arranged 2, 6, 6, 6, 6, 6, 6, 4, $60-75\ \mu$ long. Dorsal scutum with posterior margin evenly convex, AW $70\ \mu$, PW $70\ \mu$, L $101\ \mu$. 4
T. novae-hollandiae Hirst, 1929.
- Dorsal setae less than 42.

4. Posterior margin of scutum convex laterally, strongly concave medially. Dorsal setae arranged 2, 6, 6, 6 (2), 2 (6), 2. *T. weichmanni* Oudemans, 1905.
Posterior margin of scutum evenly convex.

5

5. Dorsal setae 2, 6, 6, 6, 4, 2, 2; 44 μ long. Dorsal scutum trapezoidal, AW 86 μ ; PW 94 μ , L 66 μ ; ratio PW/L 1.42.

***T. samboni* n. sp.**

Dorsal setae 2, 6, 6, 2, 2, 2; 40 μ long. Dorsal scutum AW 76 μ , PW 94 μ , L 56 μ , PW/L 1.66.

T. minor Berlese, 1904.

= *T. hirsti* Sambon, 1927.

Dorsal setae 2, 6, 6, 4, 2; 56 μ long. Dorsal scutum AW 90 μ , PW 110 μ , L 66 μ , PW/L 1.68.

T. minor Berlese, 1904.

= *T. hirsti* v. *bulolocensis* Gunther, 1939.



Fig. 2 *Trombicula samboni* n. sp.: A, dorsum; B, venter; C, palp from above; D, palp from below; E, tarsus of palp; F, mandible; G, tarsus I; H, tarsal seta.

CHYZERIA Canestrini, 1897

CHYZERIA AUSTRALIENSE Hirst, 1928

(Text fig. 3, A-E)

Description of Larva—Oval, length $234\ \mu$, width $143\ \mu$, as figured. Dorsum with one large anterior scutum and then five rows of round or oval scuta, arranged 6, 6, 6, 4, 2, each of which carries a single ciliated seta $44\ \mu$ long; the

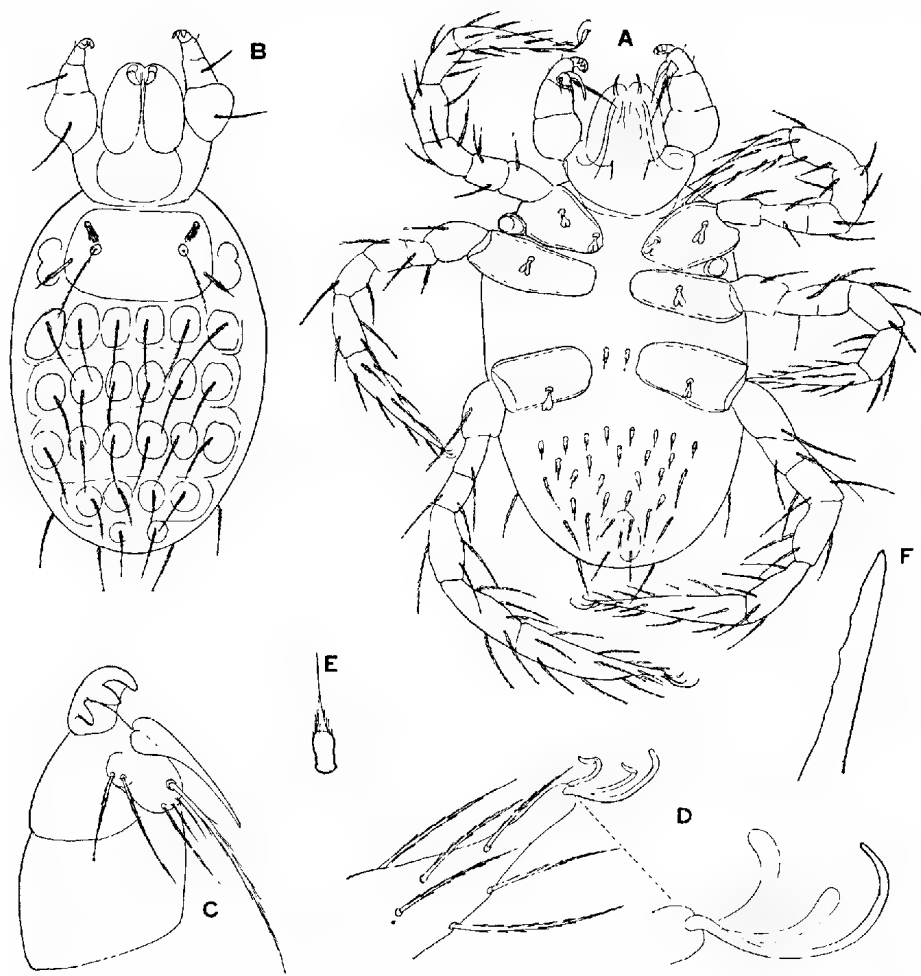


Fig. 3 *Chyzeria australiense* Hirst (larva): A, ventral view; B, dorsal view; C, palp; D, tip of tarsus and claws; E, ventral seta; F, tip of mandible.

anterior scutum is somewhat trapezoidal, AW $79\ \mu$, PW $125\ \mu$, L $52\ \mu$, and carries two pairs of setae besides the pseudostigmal setae; the anterior pair are short and stout and serrate as figured, $26\ \mu$ long, the posterior pair are thinner and more pointed and $34\ \mu$ long; the sensillary setae are fine and thread-like with fine ciliations and $44\ \mu$ long. Eyes large and two on each side close to lateral margins of anterior scutum. Palpi and mouth parts as figured; mandibles as figured, inner edge of chelae serrated.

Legs—long and stout, I 273μ long, II 286μ , III 312μ ; tarsus I 78μ by 28μ . Claws three, the lateral ones clavate as figured and shorter than the finer medial one; coxae I with 2, II and III with 1 bifurcate short stout seta.

Ventrally between coxae III is a pair of short stout setae, 13μ long, with short lateral and longer apical ciliations as figured; beyond coxae III are four rows of similar setae arranged 8, 5, 4, 4, and then 2, 6, 2, longer ciliated normal setae 20μ long. Anus is placed near apex.

Locality and Remarks—I am indebted to Mr. R. V. Southcott for this larval material. He collected two adults of the species at Glen Osmond, South Australia, on 23rd May, 1938. These he placed in a tube with a little sterile soil and although at no time was he able to observe any eggs, a number of the larvae described above appeared on 9th September, 1938. There seems to be little doubt that they can be the larvae of anything but the species to which they are here correlated.

CAENOTHROMBIUM Oudemans, 1928

CAENOTHROMBIUM MINIATUM Wom., 1934

(Text fig. 4, A-F)

Description of Larva—Length to 250μ , width 117μ ; body constricted about on level with coxae III as figured. Dorsum with two scuta, the anterior one large,

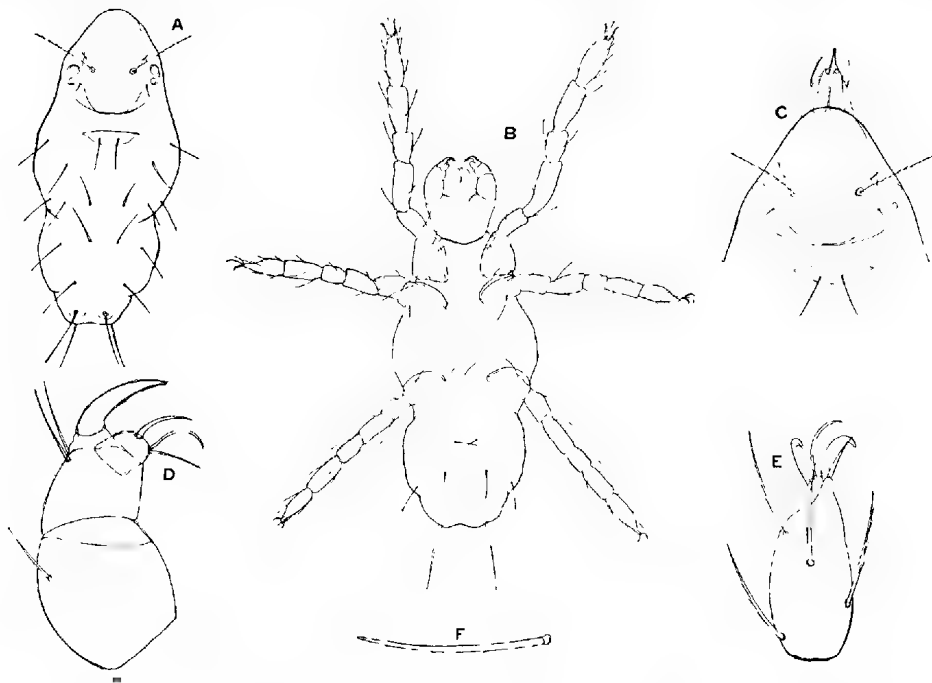


Fig. 4 *Caenothrombium miniatum* Womersley (larva): A, dorsal view; B, ventral view; C, dorsal scuta; D, palp; E, front tarsus; F, tarsal seta.

longer than wide, $78\ \mu$ by $52\ \mu$, furnished with a pair of long fine ciliated pseudo-stigmal hairs $40\ \mu$ long, the sensillary pits being slightly behind the middle of scutum; just in front of the sensillary hairs is a pair of short fine normal setae $15\ \mu$ long. The median scutum is $35\ \mu$ wide and $15\ \mu$ long, with the anterior margin almost straight, the posterior bow-shaped; it carries a single pair of fine setae about $26\text{--}30\ \mu$ long. Just outside the anterior dorsal scutum, posterior to the sensillary hairs, and between the scutal margin and the eyes is another pair of setae, of the same length. Eyes $2 + 2$, on distinct shields. The dorsum is furnished with 18 long strong fine setae, arranged 2, 2, 6, 4, 2, 2, the posterior pair are $65\ \mu$ long, the others $45\ \mu$ long.

Legs—I $208\ \mu$, tarsus $40\ \mu$ by $21\ \mu$, apparently without any simple stout spine or seta; II $182\ \mu$, III $182\ \mu$; claws strong and simple, empodium strong, claw-like. Coxae I and II adjacent, III separated, I and II with two setae, III with one. Between coxae III a single pair of setae; posteriorly, in front of anus, is a pair of setae, and on each side two setae, all these are $26\ \mu$ long; posterior of anus and terminal is a pair of long setae of $65\ \mu$; the body setae are all simple or only indistinctly serrated. The mandibles are simple. The palpi are as figured, the tibia apically having a long strong claw, the tarsus with apparently only three simple setae.

Locality and Remarks—An adult of this species was collected by Mr. R. V. Southcott on 11th September, 1938, and placed in a tube of sterile soil, as described for *Chyzeria australiense*. Eggs were observed on 1st October, 1938, and the first larva hatched on 5th November, the remainder continuing to do so until the 20th of the same month.

Guntheria n. gen.

Body form elongate oval with a distinct medial constriction. Posteriorly with an area divided longitudinally into two small oval plates each carrying three fine anterior hairs. Coxae each with a single seta. Dorsal scutum without a definite crest, uniformly pitted. Pseudostigmal hairs clavate.

Genotype—*Neoschöngastia kallipygos* Gunther, 1939.

GUNTHERIA KALLIPYGOS Gunther, 1939

(Text fig. 5, A E)

This interesting species has been very fully described by Gunther from New Guinea, and I have received specimens from Queensland collected by Mr. J. D. Smith as follows:

Slide B from Bandicoot. Slide 6 from *Rattus youngi*, No. 6, Cowan Cowan, 4th Sept., 1938. Slide 8 from *Rattus youngi*, No. 8, Cowan Cowan, 8th Sept., 1938. Slide 20 from Bandicoot, No. 70, Cowan Cowan, 6th Sept., 1938.

Gunther's material was from the following hosts: *Rattus ringens*, *R. browni*, *Melomys moncktoni*, *M. stalkeri*, *M. rubex*, *M. sp.*, *Echymipera cockerelli*, and *Peroryctes raffrayana*.



Fig. 5 *Guntheria kallipygos* Gunther: A, dorsal view; B, ventral view; C, dorsal scutum; D, gnathosoma from below; E, front tarsus.

Genus NEOSCHÖNGASTIA Ewing, 1929

In this paper it is proposed to include here only those forms in which the dorsal scutum is evenly pitted, without a prominent ridge and striations, and in which the body is not constricted medially, in addition to the characters by which Ewing separates this genus from *Schöngastia*, viz., chelicerae with not more than a single dorsal hook and trifurcate (not bifurcate) palpal claw.

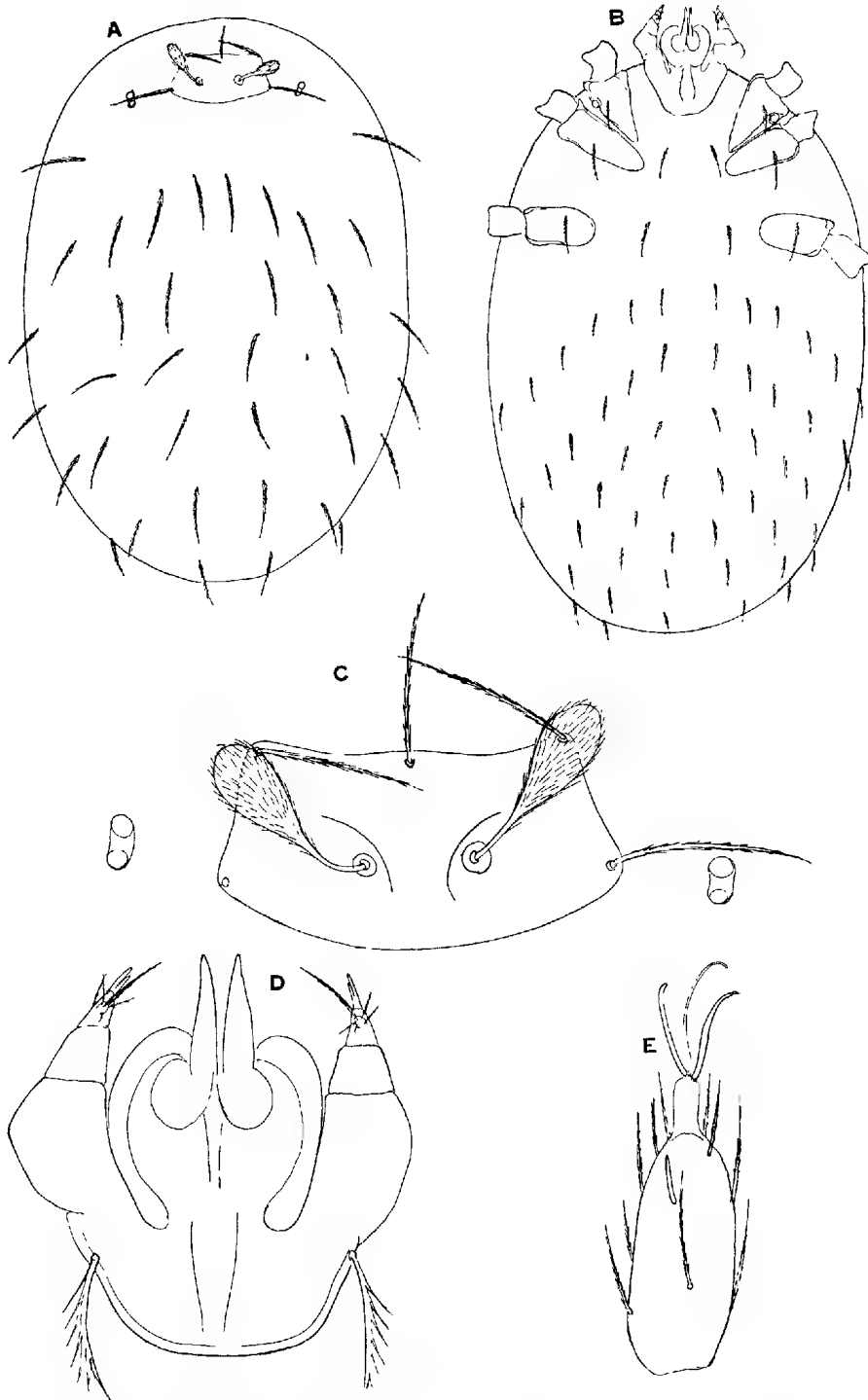


Fig. 6 *Neoschöngastia australiense* v. ***trichosuri*** v.n.: A, dorsal view; B, ventral view; C, dorsal scutum; D, gnathosoma from below; E, front tarsus.

NEOSCHÖNGASTIA WESTRALIENSE Hirst
var. **trichosuri** var. nov.

(Text fig. 6, A-E)

Description—Differs from the typical form as given in the key, in the smaller dimensions of the dorsal scutum and in the shorter dorsal setae.

Locality—Nambour, Queensland, 5th July, 1938, on *Trichosurus vulpecula*.

Neoschongastia perameles⁽²⁾ sp. nov.

(Text fig. 7, A-E)

Description—Length 550 μ , width 345 μ as figured. Dorsal scutum as figured with the greatest width, 73 μ , at half the length and in the line of the posterior

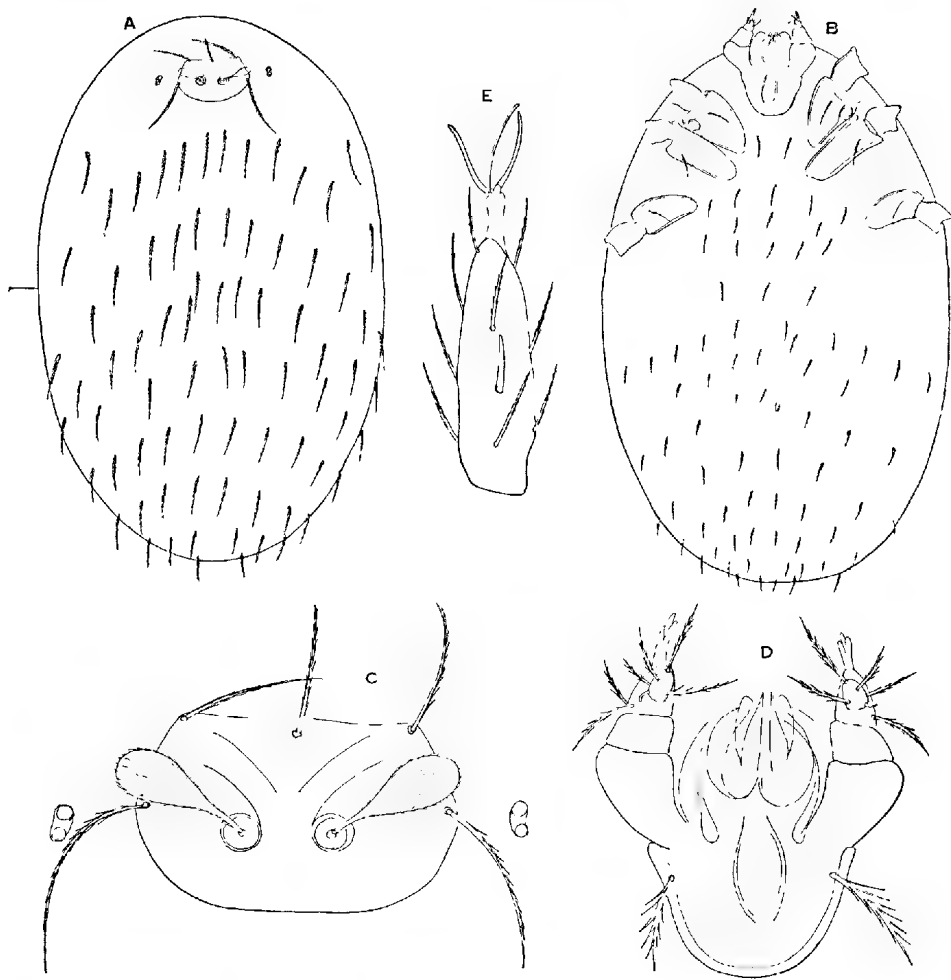


Fig. 7 **Neoschongastia perameles** n.sp.: A, dorsal view; B, ventral view; C, dorsal scutum; D, gnathosoma from below; E, front tarsus.

⁽²⁾ Owing to the prior publications of the name *isoodon* (mihi, in litt.) by Derrick in the M.J.A. for 28th Jan., 1939, contrary to Art. 25 of the International Rules of Nomenclature, this name becomes a "nomen nudum" and is, therefore, herewith changed to *perameles*.

lateral hairs; anterior width $52\ \mu$; length $47\ \mu$; posterior margin from the posterior lateral hairs deeply and evenly convex; AM seta $26\ \mu$, AL $20\ \mu$, PL $42\ \mu$; pseudo-stigmal hairs clavate as figured, $39\ \mu$ long with ciliations; scutal surface evenly pitted. Eyes two on each side on distinct plates. Palpi normal with trifurcate

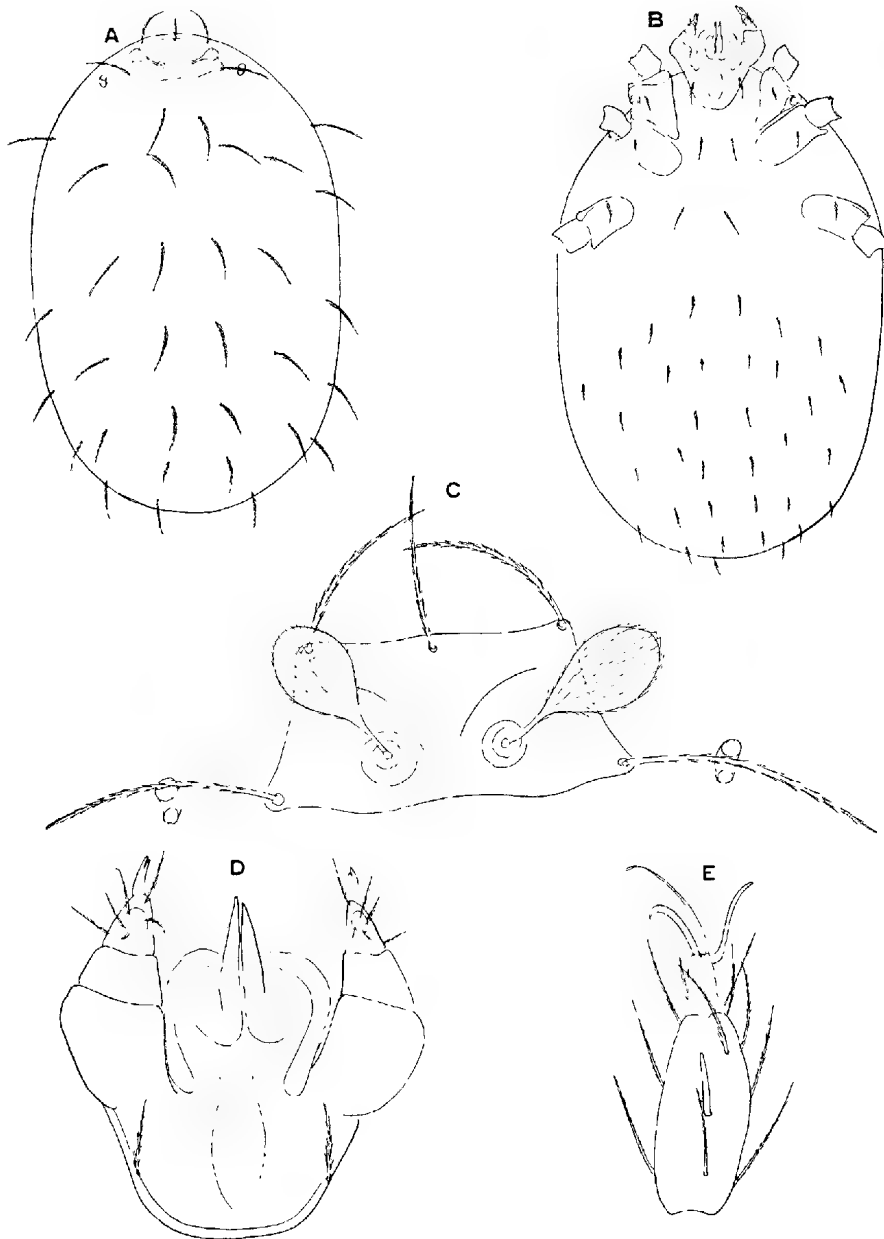


Fig. 8 ***Neoschongastia queenslandica*** n.sp.: A, dorsal view, B, ventral view; C, dorsal scutum; D, gnathosoma from below; E, front tarsus.

tibial claw. Mandibles normal. Legs—I 260 μ long, II 225 μ , III 225 μ ; tarsus I 65 μ by 20 μ , with the usual stout simple spine. Claws normal.

Dorsal setae 32 μ long, arranged 2, 12, 12, 12 (14), 10, 10, 8, 6, 2. Ventral setae 26 μ long, arranged as figured; all coxae with only one seta.

Locality and Hosts: From Bandicoots—No. 48 (slide 16) 9th June, 1938, No. 99 (17) 23rd June 1938, No. 56 (18) 21st June 1938, No. 63 (19) 10th August 1938, from Kiamba, Queensland; No. 42 (15) 27th May 1938, No. 71 (21) 10th September 1938, from Nambour, Queensland; Slide A from Brisbane, 1938, all collected by Mr. D. J. W. Smith.

Remarks—The relationships of this species are best given in the following key.

***Neoschongastia queenslandica* n. sp.**

(Text fig. 8, A-E)

Description—Length 400 μ , width 260 μ as figured. Dorsal scutum as in figure 8 A and C, with greatest width 70 μ , in line of posterior lateral hairs; anterior width 49 μ , length 26 μ ; anterior margin doubly sinuate, posterior margin doubly sinuate as figured; pseudostigmal hairs broadly clavate, 26 μ long, with ciliations; AM seta 26 μ long, AL 26 μ , PL 39 μ . Palpi as figured. Mandibles normal. Eyes two on each side, on distinct plates.

Legs—I 172 μ long, II 160 μ , III 180 μ ; tarsus I 39 μ by 21 μ , as figured; all coxae with only one seta. Dorsal setae 39 μ long, arranged 2, 6, 6, 6, 6, 4, 2; ventral setae 21 μ long, arranged as shown.

Localities and Hosts—On *Rattus assimilis* from Imbil, Queensland, 2nd July, 6th and 12th August, 1938; on *Rattus youngi* from Cowan Cowan, 4th September, 1938; on *Mecomys cervenipes* from Imbil, 19th August, 1938; on *Rattus lutreolus* from Imbil, 1st July and 4th August, 1938 (D. J. W. S.).

***Neoschongastia derricki* n. sp.**

(Text fig. 9, A-E)

Description—Length 430 μ , width 360 μ , as figured. Dorsal scutum as in figure 9 A and C with greatest width 91 μ in line with postero-lateral hairs and slightly in front of midway of length of scutum; anterior width 65 μ ; anterior margin slightly sinuate, posterior margin deeply concave and evenly curved from postero-lateral hairs; length of scutum 39 μ ; pseudostigmal hairs elongate clavate, 39 μ long. Antero-median hair 39 μ , antero-lateral 26 μ , postero-lateral hairs 78 μ . Palpi as figured, tibial claw bi- or possibly trifurcate. Mandibles normal.

Legs I 224 μ , II 250 μ , III 260 μ ; tarsus I as figured with strong stout simple spine.

Dorsal setae 78 μ long, arranged 6, 4, 6, 4, 2, with usual short ciliations. Ventral setae: all coxae with only 1, these and the pair between coxae I and those towards apex 39 μ long, remainder 26 μ , arranged as shown.

Locality and Hosts—On *Rattus lutreolus* 7, Imbil, Queensland, 4th August, 1938; on *R. assimilis* 7, Imbil, 12th August, 1938 (D. J. W. S.).

Remarks—In the characteristic dorsal setae and their arrangement this species is easily distinguished by the key.

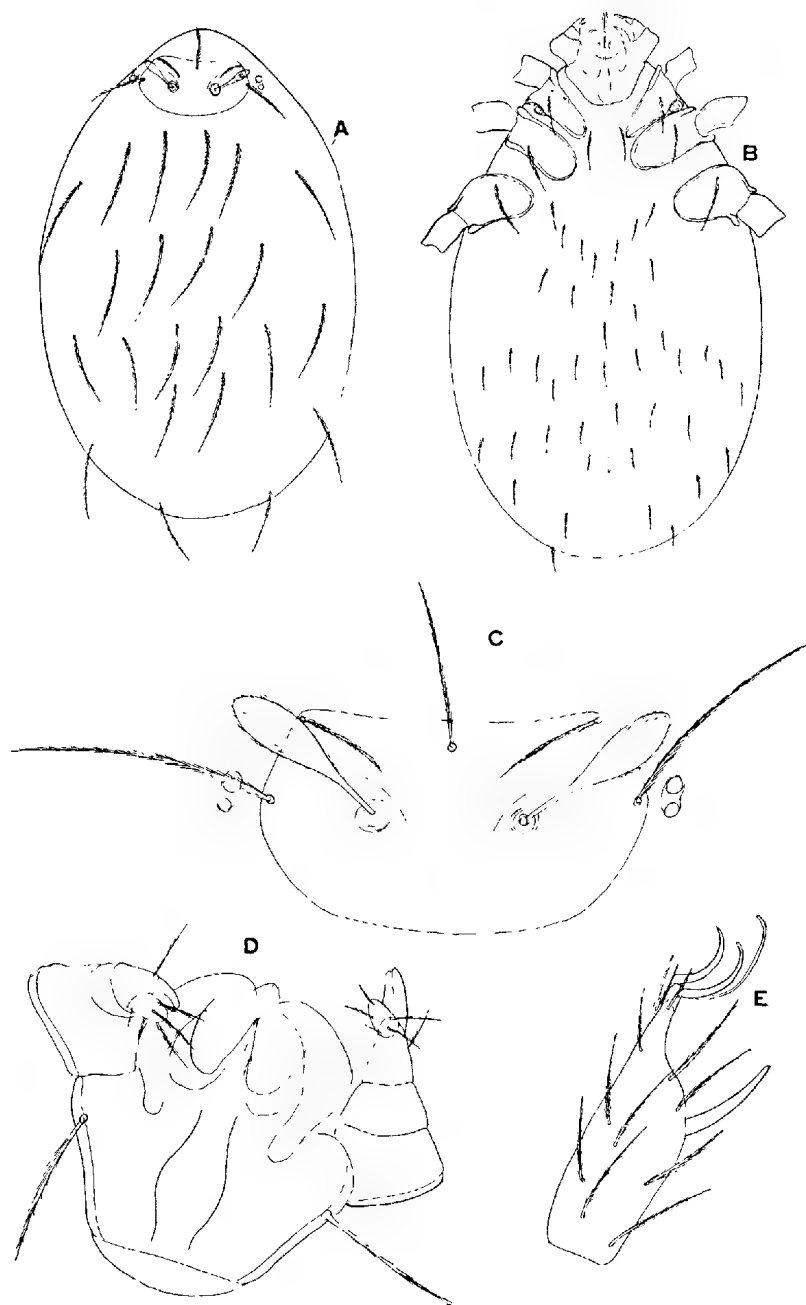


Fig. 9 *Neoschongastia derricki* n. sp.: A, dorsal view; B, ventral view; C, dorsal scutum; D, gnathosoma from below; E, front tarsus.

Neoschongastia smithi n. sp.

(Text fig. 10, A-E)

Description—Length $400\ \mu$, width $260\ \mu$ as figured. Dorsal scutum as figured, with greatest width in line of postero-lateral hairs, $78\ \mu$; anterior width $70\ \mu$; anterior margin practically straight, posterior margin evenly curved laterally, and convex in median third; antero median hair $52\ \mu$, antero-lateral $26\ \mu$, postero-lateral $65\ \mu$; pseudostigmal hairs $60\ \mu$ long, elongate clavate. Eyes $8 + 2$, on distinct shield and only slightly distant from the scutum. Palpi as figured, mandibles normal.

Legs—I $260\ \mu$ long, II $224\ \mu$, III $260\ \mu$; tarsus I $57\ \mu$ by $18\ \mu$ as figured. Claws normal.

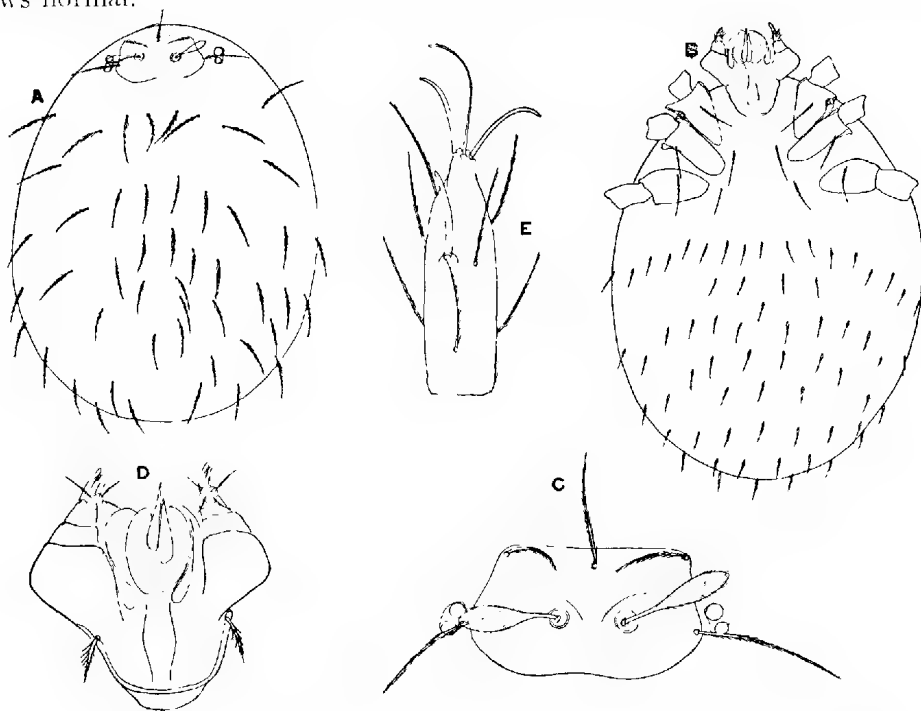


Fig. 10 **Neoschongastia smithi** n. sp.: A, dorsal view; B, ventral view; C, dorsal scutum; D, gnathosoma from below; E, front tarsus.

Dorsal setae $52\ \mu$ long, arranged 2, 8, 8 (10), 8 (10), 6 (8), 4, 4, 2; ventral $20\ \mu$ as figured. All coxae with only one seta.

Locality—On *Rattus assimilis* (7) from Imbil, Queensland, 12th August, 1938 (D. J. W. S.).

KEY TO THE AUSTRALIAN AND NEW GUINEA SPECIES OF NEOSCHÖNGASTIA

- | | |
|--|---|
| 1. Pseudostigmal hairs more or less globular. | 2 |
| Pseudostigmal hairs clavate. | 6 |
| 2. Posterior margin of scutum convex or produced backwards, so that the postero-lateral hairs are much in advance of the mid-point of the margin. | 3 |
| Posterior margin of scutum almost straight or somewhat sinuate medially; postero-lateral hairs hardly if at all in advance of mid-point of margin. | 5 |

3. Dorsal scutum roughly hexagonal, the posterior margin forming strong angles with lateral margins, the outer thirds at about 45° with middle third which is straight and slightly sinuated. Pseudostigmal hairs in a transverse line with postero-lateral hairs. Dorsal setae 64, arranged 2, 14, 14, 10, 12, 8, 4; 26μ long.
N. edwardsi Gunther, 1939
 Dorsal scutum more trapezoidal, not forming acute lateral angles. 4
4. Posterior margin of dorsal scutum laterally rounded and medially concave. Dorsal body hairs 32, arranged 2, 6, 6, 6, 6, 4, 2; 50μ long. *N. coorongense* Hirst, 1929
 Posterior margin straighter, slightly sinuate medially, posterior corners broadly rounded. Dorsal body hairs about 100, 35μ long and much more ciliated, arranged in about 10 rows of 10-12 hairs.
N. petrogale Wom., 1934
5. Anterior margin of dorsal scutum not more than two-thirds length of posterior margin. Dorsal body hairs 39 μ , arranged 2, 6, 6, 6, 6, 4 (2), 2. Posterior margin of dorsal scutum 70μ long.
N. queenslandica n. sp.
 Anterior margin of dorsal scutum four-fifths length of posterior margin. Dorsal body hairs 50, 36μ long, arranged 6, 8, 8, 8, 8, 6, 4, 2. Posterior margin of dorsal scutum 70μ long.
N. antipodianum Hirst, 1929
6. Dorsal scutum three-fourths as long as wide. 7
 Dorsal scutum three-fifths or less as long as wide. 8
7. Posterior margin of dorsal scutum evenly convex. Bases of pseudostigmal hairs in line with postero-lateral hairs. Dorsal body hairs 40μ long, arranged 2, 8, 6, 6, 6, 2, 2.
N. dasycerci Hirst, 1929
 Posterior margin of dorsal scutum rather flattened or feebly sinuate in middle third. Bases of pseudostigmal hairs much in advance of postero-lateral hairs. Dorsal body hairs 26μ long, arranged 2, 6, 6 (2), 6, 4, 2 (2).
N. impar Gunther, 1939
8. Dorsal scutum three-fifths as long as wide, posterior margin slightly convex on lateral thirds, strongly concave on middle third. Bases of pseudostigmal hairs much in advance of postero-lateral hairs and nearer the antero-lateral hairs than to the postero laterals. Dorsal body setae 30μ long, arranged 2, 6, 6, 4, 2 (4), 2.
N. lorius Gunther, 1939
 Dorsal scutum not more than half as long as wide. 9
9. Posterior margin of dorsal scutum concave medially, anterior margin concave. Dorsal body setae 51-79 μ long, arranged 2, 8, 6, 6, 6 (4), 4 (6), 2. 10
 Posterior margin of dorsal scutum not noticeably concave medially. 11
10. Width between postero-lateral hairs of dorsal scutum 106μ . Dorsal body hairs 79μ long.
N. westraliense Wom., 1934
 Width between postero lateral hairs of dorsal scutum 79μ . Dorsal body hairs 51μ long.
N. westraliense v. *trichosuri* n. v.
11. Dorsal scute angular laterally on a level of the postero-lateral hairs. Pseudostigmal hairs in line with the postero-lateral hairs, distance between latter 89μ . Dorsal body hairs 70μ long, arranged 6, 6, 6, 4, 2.
N. derricki n. sp.
 Sides of dorsal scutum straight or nearly so, not angled. 12
12. Dorsal body hairs about 50, arranged 2, 8, 8, 8, 8, ?, 52μ long. *N. smithi* n. sp.
 Dorsal body hairs about 80 in all, 34μ long, arranged 2, 12, 12, 12, 12, ?.
N. perameles n. sp.

Genus *Paraschongastia* gen nov.

This new genus is erected for the four New Guinea species described by Gunther as belonging to *Neoschöngastia*, but then recognised as forming at least a well-defined group.

The anterior dorsal scutum differs from that of species of *Neoschöngastia* in that there is a distinct raised crest in front of the pseudostigmata. This crest forms a very distinct wall in which the bases of the sensillary hairs are situated. The posterior half of the scutum on each half has circular striations but the anterior half is pitted. Coxae III with 1, 2 or 3 ciliated hairs along anterior margin.

The four species so far known can be separated by the following key:

KEY TO THE AUSTRALIAN AND NEW GUINEA SPECIES OF *Paraschöngastia* gen. nov.

1. Coxae III with three ciliated hairs along anterior margin. No pitted area posteriorly on dorsum. Dorsal setae 2, 14, 10, 12, 6, 14, 14, 12, 8, 4. Scutal crest indefinite medially. *P. dubia* Gunther, 1939

Coxae III with only one or two ciliated setae on anterior margin.

2. Coxae III with two ciliated setae on anterior margin. Posterior pitted area of dorsum relatively small with a number of slightly oval discs each bearing a single fine hair; along anterior margin of this area a row of tubercles devoid of hairs.

P. retrocineta Gunther, 1939

Not as above, coxae III with only one ciliated seta.

3. No distinct pitted non-striated area posteriorly on dorsum. Dorsal setae 2, 14, 14, 10, 8, 8, 6, 6, 2, 2. *P. megapodius* Gunther, 1939

Dorsum posteriorly with a distinct pitted but non-striated area, on which the hairs arise from tubercles. Dorsal setae 2, 16, 8 (10), 12 (10), 10 (8), 8 (10), 12, 6, 6, 6, 4.

P. yeomansi Gunther, 1939

Genus SCHÖNGASTIA Oud. 1910, Ewing 1929

No species of this genus in the restricted sense of Ewing have as yet been recorded from Australia, but the following three species are known from New Guinea.

KEY TO THE NEW GUINEA SPECIES OF SCHÖNGASTIA

1. Dorsal body setae more than 50.
Dorsal body setae 40, arranged 2, 12 (8), (4) (6), 4, 2, 2; 50 μ long. *S. jamesi* Gunther, 1939

2. Dorsal body setae 52, arranged 2, 10, 10, 10, 10, 8 (10), 2 (10). Palpal claw bifurcate. *S. van der sandei* Oudemans, 1905

Dorsal body setae 64, arranged 2, 10, 8, 10, 8 (10), 10 (8), 8, 8; 40 μ long. (According to Gunther the eighth row is frequently ventral.) Palpal claw bifurcate.

S. blestowei Gunther, 1935

NOTES ON THE DIERI TRIBE OF SOUTH AUSTRALIA

By R. M. BERNDT and T. VOGELSANG, South Australian Museum

Summary

Howitt (1904), Gason (1879), Reuther, Strehlow and Basedow (1925) have notably contributed to our knowledge of the Dieri Tribe. The present notes are an addition to the work of these men.

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By R. M. BERNDT and T. VOGELSANG
South Australian Museum

[Read 13 July 1939]

INTRODUCTION

Howitt (1904), Gason (1879), Reuther, Strehlow and Basedow (1925) have notably contributed to our knowledge of the Dieri Tribe. The present notes are an addition to the work of these men.

The Dieri Tribe inhabits the eastern shores and neighbouring country of Lake Eyre. It is divided into two groups, the Cooper's Creek Dieri or [Ku'na: ri], and the Lake Hope Dieri or [Pandu], these being bordered by the Ngameni, Jauraworka and Jantruwanta tribes.

Basedow (1925, p. 14) records that, around the Lake Eyre region which embraces the above tribes, the population forty years ago numbered many thousands. More recently, however, during a survey of this country (just prior to 1925), he states that only a bare three hundred could be mustered. Today a considerably smaller number remain.

Much of the information recorded in this paper is the direct observation of T. Vogelsang, who was born in the Dieri Tribe country and lived there for many years, making friends with the aborigines. He thus had an excellent opportunity of observing the manners and customs of these people.

PRELUDE TO A FIGHT

If a quarrel started between two natives and one referred to the sexual parts of a male or female relative of the other, a fight would ensue. Such words were considered to be particularly bad form and were rarely used, but once uttered, aroused the whole camp. Another offence that would most certainly cause a fight would be the mention of the name of a dead relative of the opponent.

A QUARREL

If, during the course of a fight, the stronger was getting the better of his weaker opponent, the latter, awaiting his opportunity, would place his hands upon the other's hips, thumb and first index finger outstretched, and give a slight pressure, speaking at the same time the word [matja] (enough). This action would immediately stop the fight.

A fight which had been stopped in this manner would not be resumed, the fighters departing on friendly terms.

WOMAN'S PART IN A QUARREL

Another method of stopping a quarrel was by beseeching pleas from a woman, or women, as the case may be. They possessed great power over the

men fighting, particularly in the case of a quarrel between the tribal groups, and were the only ones who could bring such to an end.

In warfare between the groups of the Lake Eyre region, women would not be touched. If they desired to stop the advancing enemy, they would dance in front of them, cutting themselves as they did so. The men would then feel sorry for the women and would cease their attack. After this, women were often loaned to the warriors.

Women were also loaned to visiting groups, whose advent would be heralded with much noise and beating of ground. Although only visitors, such groups had the appearance of hostile men.

In earlier times, before the influence of the missionary, almost every man had access to other women, besides his wife, this relationship being governed by tribal law.

This corresponds to that mentioned by Spencer and Gillen (1889, p. 109) in describing the *piraungaru* system of the Arabana tribe on the western shores of Lake Eyre, which is similar to the *pirauru* of the Dieri (Howitt, 1889, p. 96). Such a system designates a limited number of men and women who may lawfully have extra-marital relationship.

Although not relevant with the above, it can be stated here that a dance, which as far as is known, was not ceremonial, was performed at night around the camp, during which free intercourse between the two sexes occurred. On these occasions, the normal sexual restrictions were somewhat relaxed.

Howitt (1904, p. 185) mentions that the marriage between a Dieri man and a woman of the Mardula (*i.e.*, Wailpi) tribe being arranged, a place near the boundary between the two tribes was fixed upon, where a ceremony was held. The festivities were kept up for several days, during which free intercourse was allowed between the sexes, without regard to existing marriage relations.

DRINKING BLOOD

The younger men, who had not before been in any battle, were instructed by the tribal elders to drink the blood of an enemy killed in battle. The congealed blood, ground down to a powder and mixed with water, was believed to give them additional strength and a taste for future fights. It was also considered a standard of manhood. Those who had previously drunk blood would not be obliged to do so again. This custom was not associated with the initiation ceremonies.

Spencer and Gillen (1899, p. 461) record that in the Aranda and Ilpirra tribes, when starting on an avenging expedition, every man of the party drinks some blood taken from a selected man.

Howitt (1904, p. 751) states that the Bunurong (of Victoria) not only cut flesh off the legs and arms of killed enemies, but, according to their neighbours, the Wurun-jerri, they also drank the blood of their slain enemies.

The drinking of blood, when practised, appears generally to have been with the view of strengthening the drinker.

DEATH

Upon the death of a native, his camp would be deserted but not burnt. If a man knows he is about to die, he gives his possessions away. If not, neither his relatives nor any member of the camp will use them, and there is an even stronger prohibition on the use of the dead man's name.

DISPOSAL OF THE DEAD

The disposal of the dead has been narrated by Gason (1874, p. 22) and by Howitt (1904, p. 446), but the following extract of a translation from the German in "History of the Lutheran Mission" (1886, p. 17) differs in some details from that already recorded.

"The two large toes of the deceased Dieri aborigine are tied together, and then the whole body is sewn into a net. There is no particular place set aside for the grave, but generally, the body is taken to a place where the ground is the easiest to dig. Usually the excavation is about four feet deep.

"Then the body is carried on the heads of three men and laid down at the graveside. Again it is placed on the heads of these men, who then kneel. An elderly man, holding in each hand a thin rod, steps opposite the body, and asks it who or what has been the cause of its death, believing that the dead person will answer this question. Any one of the three men may act as interpreter, and give the answer, which is usually the name of a person in another tribe who is probably disliked.

"As soon as the person has been named, the bearers throw the body to the ground, and then begins a terrible noise of wailing.

"The body is placed within the grave and covered with bushes and pieces of wood, the last so that the wild dogs cannot uncover the remains."

Howitt (1904, p. 446) differs from the above description mainly in that the men sitting around—not the three body-bearers—act as interpreters for the deceased. Both this author (1904, p. 751) and Roheim (1925, p. 97) mention the ceremonial eating of the dead.

The following is additional information on the disposal of the dead:

To make certain that the person is dead, the body, when carried to the grave on the heads of the three bearers, is dropped on the ground in such a way that the neck is broken.

The interpreter of the dead man's answer to the elder's question sometimes used the art of ventriloquism, the voice appearing to come from the dead body itself. Attendant mourners and onlookers at this inquest viewed the dead man's answer as the natural thing to happen, as it was essential that the person, not the group, who caused the death should be named. Howitt (1904, p. 448) also states that the name of some native of another tribe is given.

The body was interred at full length, with the head towards the north, that is, face looking south. According to a native legend, the dead man's spirit leaves the body at death and travels underground to the south, and shortly afterwards returns to the body in the grave, but, at that time, does not stay with it. It is believed that, at some undefined period, the spirit will again inhabit the body.

Food which might be consumed by the visiting spirit was sometimes left at the graveside.

The two large toes of the deceased are tied with fibre, and the whole wrapped in a net. Leaves of bushes or grass are used to line the grave, and, after interment, pieces of wood, bushes, or twigs were placed on top. Sometimes sand and dirt completed the mound, which was about two feet in height. The mound often became higher and larger on account of loose drift sand accumulating amongst the bushes and twigs.

If a man committed an offence contrary to the tribal law and was put to death, he would be buried in the same manner as other members of the tribe, but there would be no mourning ceremonies.

MOURNING

All the people of the tribe mourn for the first night, but afterwards the relatives only of the dead person continue. This mourning consists of a great deal of wailing, and, in the case of the women, the cutting of their flesh. The bodies of both men and women are smeared with pipe-clay.

In some of the Central Australian tribes, it is said that the object of painting the body of a mourner is to render him or her more conspicuous, so allowing the spirit to see that it is being properly mourned. (Spencer and Gillen, 1889, p. 511.) The mourning must be continuous and whole-hearted in order to pacify the spirit of the deceased.

Mourning songs, consisting of the repeated chanting of two or three words, alternately soft and loud, continue for some weeks. The greatest amount of grief is displayed at the death and burial of the elder members of the community, but the mourning ceremonies of decrepit men and women are short, while still-born and young children are buried without any mourning, and the ground levelled. Stillborn children were frequently eaten.

There is no evidence of collective or tree burial, and cremation or smoke drying was not practised.

RAINMAKING

The bull-roarer [*'janta*] was used in connection with rainmaking. Howitt (1904, p. 394) has written of rainmakers and their importance during the frequently recurring periods of droughts.

An elder of the Dieri had custody of the bull-roarer, which was kept from public view. He was known as the rainmaker, and it was his duty to manipulate it during the ceremony. The article was nearly always regarded as an object of magic, and there were restrictions on the showing of it to women and uninitiated youths.

Another way of causing rain was by rubbing goanna fat into the body of a boy; the grease causing steam to rise from the body. This was supposed to form into a cloud from which rain would fall. Upon one such occasion, states T. Vogelsang, the boy happened to be the son of the rainmaker.

Grease is often associated with the making of rain, and is used in many ceremonies of this kind in Australia.

Howitt (1904, p. 799) narrates the Darana legend, which is connected with two heart-shaped stones kept by the Dieri. These stones are believed to be senders of rain, and in the rainmaking ceremonies are smeared with fat, while Roth (1897, p. 158) states that in North-West Central Queensland, a sacred stone was anointed with fat when asking it for rain.

AN OMEN

If one's nose was itching, the native believed that this was an infallible sign that a relation would soon arrive at the camp.

DISCUSSION

In spite of the attention that has been already given to the subject, the following points as to the actual origin or motif of these customs should be deserving of further investigation:

- (a) The action used by one native to another in order to stop the fight.
- (b) The lending of women to groups and a probable hypothesis of group-marriage. (Howitt, 1904, p. 179.)
- (c) The drinking of blood in order that strength might be obtained.
- (d) The prohibition on the deceased's name.
- (e) The use of the art of ventriloquism during the inquest ceremony.
- (f) The only type of burial practised being earth burial.
- (g) The mourning ceremonies depending largely upon the age and social standing or status of the individual concerned.
- (h) The use of grease in rainmaking ceremonies, and the native idea of steam causing rain to fall.
- (i) Many omens must exist, although they have hitherto received little notice.

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ABORIGINAL NAMES AND USES OF PLANTS IN THE NORTHERN FLINDERS RANGES

By J. B. CLELAND and T. HARVEY JOHNSTON
Board for Anthropological Research, University of Adelaide

Summary

The information contained in the present communication was obtained during our visit to Nepabunna and adjoining regions in the Northern Flinders Ranges in May, 1937. Our chief informants were Ted Wilton (Native name, Warri), Albert Wilton, and Archie MacKenzie, members of the Anyamutina (Unyamutna) or Wailpi and Parnkala (Bahnga-la) tribes. The former tribe ranged as far south as Blinman, while the latter occupied territory further south, including Hawker.

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FILICALES

Pleurosorus ruscifolius (R. Br.) Fée. Maire-ruta.

PINACEAE

Callitris glauca R. Br., Native Pine. Vin-ba; not used.

GRAMINEAE

General terms for grass. Ngaru (Nguru).

General name for seeds. Pau-a (vau-a).

Digitaria Brownii (R. et S.) Hughes (= *Panicum leucophavum* Benth.) Yu-tara.

Paspalidium gracile (R. Br.) Hughes and *Panicum decompositum* R. Br. In both cases the names had been forgotten by our informant. The seeds were used.

Stipa variabilis Hughes. A speargrass. Yutara; not used (see *Digitaria*).

Pappophorum avenaceum Lindl. Vairi oota, or oota; seed ground for food. Another kind of grass. Mairi oota (see *Pappophorum*).

Eragrostis sp. Love-grass. Yutara (see *Digitaria*, etc.).

Trioda sp. Vak-ari. Occurs on the hills; only one kind is known in this region. Used at camps (angu = camp) for a bed in the wurlic (= wilya). The seeds are ground.

Astrebla pectinata F. v. M. Mitchell Grass. Seeds ground and eaten.

Dactyloctenium aegyptium (L.) Willd., Nguru (seed) ground with a large or small grinding stone (wadla or wadla rappa), respectively, then cooked and eaten.

CYPERACEAE

Cyperus vaginatus R. Br. Widna.

Cyperus Gunni Hook f. Ooru.

Cyperus rotundus L. Yelka; A-la. Reported as not growing in this region.

LILIACEAE

Dianella revoluta R. Br. Vu-ru. The stems are pounded to make a fine fibre and are then held in the hands and clasped around the flowering stem of the yacca (*Xanthorrhoea*) to collect honey from the flowers. Children eat the white leaf bases.

Bulbine sp., Native Onion Weed. Ana-lilli-lilli. See also *Lotus australis*.

Xanthorrhoea quadrangulata F. v. M. Ardla-uru. The gum (gnura) is used (after heating) for fixing weapons, attaching stone axes to their hafted handles, etc. The term ardla is said to mean fire. For uru see also *Cyperus Gunni* and *Dianella*.

CASUARINACEAE

Casuarina lepidophloia F. v. M. Black Oak. Alku.

URTICACEAE

Urtica sp. (nettle). A new-comer, i.e., an introduced plant, hence no native name.

PROTEACEAE

H. Ednicana Tate. Yandana.

Hakea leucoptera R. Br. V(w)erna. The roots are used for obtaining water. Pieces about three or four feet long are stood on end in a rock cavity or a receptacle for half-an-hour or more to collect the water. Often fire is used to heat one end of the root first.

SANTALACEAE

Exocarpus aphylla R. Br. Artara. Not used.

Eurarya acuminata (R. Br.) Spr. et Summ. Native Peach. Wurti. Native peach seed, wurti muku. The kernel of the "stone" is eaten as well as the pulp, wurti mai-i (mai-i = the edible pulp of fruits).

Eucarya spicata (R. Br.) Spr. et Summ. True Sandal wood. Oordluru.

LORANTHACEAE

Loranthus exocarpus Behr. Wertibi, wertabi, wertipi. The fruit, Yappi wertibi (yappi means fruit).

Loranthus Maidenii Blakeley (on *Acacia aneura* var. *latifolia*). Mulka wertibi, i.e., wertibi from mulga. The fruit (?) is boiled in a receptacle (formerly heated with hot stones in receptacles called burnda), strained, cooled and then drunk (an amount that would go into a hollowed hand) three times a day. Used for inflammation of the genital region in males and females. This information suggests a European origin, such use probably being suggested by the mucilaginous fruit. Note the "three times a day."

CHENOPODIACEAE

Chenopodium cristatum F. v. M. Leaves slightly scented. Seeds not used.

Chenopodium album L. Fat Hen (introduced). A "newcomer"; no name.

Rhagodia parabolica R. Br. Old-man Saltbush. Nilpena (note that this is the name also of a station).

Atriplex vesicarium Hew. (?) Willa kura.

Bassia longicuspis F. v. M. Yelkari.

Bassia paradoxa (R. Br.) F. v. M. Urtu (= prickly); not used.

Bassia sp. (2-spined species). Woma-era.

Kochia sedifolia F. v. M. Bluebush. Il-la; not used.

Salsola kali L., Buckbush. Yilka. Children and adults break off dry pieces of a branch, about one-quarter inch long, press one end into the skin to make the stem stand upright, and then set alight to the other end. The twig burns slowly and makes, on the skin, a rounded burn which is considered an ornamentation.

Babbagea sp. Numminya-numminya.

Enchylaena tomentosa R. Br. Ruby Saltbush. Wool-ami. Berries sometimes eaten.

AMARANTACEAE

Trichinium exaltatum (Nees.) Benth. Wildida, reldelda.

NYCTAGINACEAE

Boerhavia diffusa L. Aru-wirri. Root cooked in ashes and then eaten.

PHYTOLACCACEAE

Codonocarpus pyramidalis F. v. M. Alyunga.

AIZOACEAE

Tetragonia expansa Murr. Native spinach. No name available. Used as a source of moisture in steaming cresses (see under Cruciferae). Not utilized as a food formerly by the natives, but now used after boiling (or after cooking in a hole).

PORTULACACEAE

Portulaca oleracea L. W(v)idla verka, wirla. Seeds ground for food, stems chewed in dry times. Plant cooked in ashes like spinach and *Boerhavia*.

CAPPARIDACEAE

Capparis Mitchellii Lindl. Native Orange. Iligga; fruit eaten.

CRUCIFERAE

Lepidium rotundum DC. Werkundu. Steamed in the following manner and then eaten. Fire and hot stones are placed in a hole; then spinach (*Tetragonia expansa*) is put in the bottom of the hole or on top of the hot stones, then the cress, succeeded by more spinach, then hot stones are placed on top and the whole is covered with sand and left for about an hour.

Lepidium oxytrichum Sprague. Kuppinupinya.

PITTOSPORACEAE

Pittosporum phillyreoides DC. Ma-tu; not used.

Bursaria spinosa Cav. Mapalu.

LEGUMINOSAE

Acacia Victoriae Benth. Min-ga.

Acacia rivalis J. M. Black. Silver Wattle. Nguri. The fairly plentiful gum is eaten; the seeds are ground and eaten.

Acacia salicina Lindl. Broughton Willow. W(v)alkuru, ulkuru, relkura.

Acacia tetragonophylla F. v. M. Vaira (vera).

Acacia Oszwaldii F. v. M. Oolka; seeds eaten.

Acacia aneura F. v. M. Mulga. The native name has become corrupted to mulga. The seeds of mulgas and other *Acacias* were formerly ground and eaten. Gum from *Acacias* (but not from the native pine, *Callitris*) is eaten. The twigs of various species of *Acacia* are used for obtaining ash for mixing with pituri. Barbed spears made of mulga are called wardla-ta. The following, except (4) *A. Kempeana*, are apparently all forms of the composite species, *A. aneura*, and are given different names by the natives:

- (1) Mulga with broad phyllodes and grey foliage; red wood; brownish glaucous branchlets; slightly curved phyllodes, 5.5 to 6 x 0.5 cm. Munye-minimi.
- (2) Mulga with long narrow flattened yellowish phyllodes; medium brown wood; brownish glaucous branchlets; linear, slightly curved phyllodes, 9 to 10.5 cm. x 2 to 3 mm. Wunni-wychi, wunni waitjena.
- (3) Common grey mulga with long narrow grey-green flattened phyllodes; blackish wood; smoother, reddish glaucous branchlets; linear phyllodes, 6.5 to 10 cm. x 2 to 2.5 mm. Millilu.
- (4) *Acacia Kempeana* F. v. M. Mulga with short broad phyllodes, slightly curved, 3 to 3.5 cm. x 3.5 mm. Mulpurru, nulpuru.
- (5) Mulga with long narrow linear phyllodes, brownish (but not polished) branches and leaves rather narrower and less flattened than in (2); foliage slightly yellowish; wood medium brown; branchlets reddish glaucous; phyllodes nearly terete, 10.5 to 12 cm. x 2 mm. Ardla-ti.

Cassia Sturtii A. Br. Unila, walnina.

C. cremophila A. Cunn. Murrku; seeds eaten.

Lotus australis Andr. var. *parviflorus* Benth. Ani-lirri-lirri. (See also *Bulbine* sp.)

Psoralea patens Lindl. Fibre used for net-making.

Clianthus speciosus (G. Don) Aschers et Graebn. Sturt's Pea. Murra punna.

Templetonia egea (F. v. M.) Benth. Broom Bush. Vigni (Veenyee). Used for covering game traps dug along wallaby pads to catch smaller macropods (rock wallabies and euros).

ZYGOPHYLLACEAE

Zygophyllum, all species (several were collected). Midti (mid-di) ; not used.
Tribulus (*T. terrestris* L. and *T. occidentalis* R. Br. were collected). Eeta (= prickly).

SAPINDACEAE

Heterodendron oleifolium Desf. Bullock Bush. Minera. The red tissue between the spherical black seed and the capsule is eaten fresh. The twigs are used for supplying ash to be used in preparing pitpuri for chewing.

Dodonaea attenuata A. Cunn. Wawaru.

MALVACEAE

Lavatera plebeja Sims. Woolma; fibre used for string.

Malva sp. Marsh Mallow. Woolma; used for poultices.

Malvastrum spicatum (L.) A. Gray. Wuthari, ut-(h)a; not used.

Sida intricata F. v. M. (W)udari. See also *Malvastrum* and *S. petrophila*.

Sida petrophila F. v. M. (probably). Ur-dari.

Abutilon leucopetalum F. v. M. Woolma (oolma), same name as given to *Lavatera* and *Malva*, but the difference between these plants is recognised.

Hibiscus Huegelii Endl. Native name forgotten by interpreter; plant not used.

THYMELEACEAE

Pimela microcephala R. Br. Wirri-pirri, wilpari, wilpiri. Bark removed, plaited and put around the neck as a cure for colds. Ripe berries eaten.

MYRTACEAE

Melaleuca pubescens Schau. Black Tea-tree. Wuta.

Melaleuca sp. ("white Tea-tree"). Al-arui.

Melaleuca glomerata F. v. M. and *M. linophylla* F. v. M. Ooda. The two species are recognised as different but the same name is applied to both, as well as to *M. pubescens*.

Eucalyptus intertexta R. T. Baker. Box. Yundu, Yunta. Seeds ground and eaten.

Eucalyptus oleosa F. v. M. and *E. transcontinentalis* Maiden. Madla, mudla. This name is applied to any kind of mallee with rough bark on its stem. The lerp (Psyllid) from *E. oleosa* is edible and is termed How-arce.

Eucalyptus Gillii Maiden. and other mallees with smooth stems. Ada ada, awilla awilla, mundu-warra; not used.

Eucalyptus rostrata Schlecht. Red gum. Wirra; seeds not used. The witjeti grub (larva of a large moth) occurring in the roots is eaten and is called Wai-api. Red gum, mallee and box were used formerly for obtaining wooden or bark dishes (food vessels). The native name of the red gum appears in that of the townships Oodla Wirra and Wawirra.

UMBELLIFERAE

Didiscus glaucifolius F. v. M. Called a "new-comer" by our informant, hence no native name.

PRIMULACEAE

Anagallis sp. Pimpernel, introduced. A "new-comer," hence no native name. Regarded as poisonous.

ASCLEPIADACEAE

Marsdenia australis (R. Br.) J. M. Black. Nundi, nandi (the creeper), mai-aka (the fruit); eaten either raw or cooked.

Cynanchum floribundum R. Br. Name forgotten by our informant. Fruit and seeds eaten.

OLEACEAE

Jasminum lincare R. Br. Ngamaruka. Mr. C. P. Mountford informs us that this plant is considered by the local aborigines to be the food of the "Muri" (spirit child).

CONVOLVULACEAE

Convolvulus erubescens Sims. Nyunya, oonya.

BORRAGINACEAE

Heliotropium europaeum L. Potato Weed. Ardu-mai-i.

Trichodesma zeylanicum (Burm.) R. Br. Uru-lundula.

LABIATAE

Ajuga australis R. Br. Bugle. Wulpa-werta.

Prostanthera striatiflora F. v. M. Vau-uru.

SOLANACEAE

Solanum nigrum L. A "new-comer," hence no name.

Solanum Sturtianum F. v. M. Windari.

Solanum petrophilum F. v. M. Urlumbu; not used. Name apparently the same as that applied to the following species.

Solanum sp. (with few prickles). Alanu; fruit not eaten.

Solanum ellipticum R. Br. Immaru; fruits eaten.

Datura stramonium L. A "new comer."

Nicotiana velutina Wheler. Uro-rindju-lu; now utilized by the natives when short of tobacco, the leaves being used when somewhat dried off on the plant.

Nicotiana glauca Grah. Introduced Tree Tobacco. A "new-comer" (no name).

Pituri is (or was) used in the locality but the natives do not know the plant, *Duboisia Hopwoodii*, from which the material is derived, as the supply of the prepared product was traded from the north through the Lake Eyre region.

MYOPORACEAE

Myoporum platycarpum R. Br. Imburu. The gum, gnuri, is used for fixing weapons and closing holes.

Eremophila longifolia (R. Br.) F. v. M. Verti werka; Vada waka. See also *Eucarya acuminata*.

Eremophila Sturtii R. Br. (?). Langdu; nectar used.

Eremophila scoparii (R. Br.) F. v. M. Wi-uka; not used.

Eremophila sp. (with linear leaves). Alkata.

Eremophila glabra (R. Br.) Ostenf. Ooli-werdi.

Eremophila sp. (with green flower). Ooli-werdi.

CAMPANULACEAE

Wahlenbergia spp. (*W. Sieberi* A. D. C. and *W. multicaulis* Benth.; both were collected). Warri wirra.

GOODENIACEAE

Scaevola spinescens A. Br. Yudli. The fruit is highly prized and eaten. The leaves and branches (both dry and green) are placed in a hole in the ground, burnt, and the boy who has been circumcised recently then squats over the hole and micturates into the hot ashes there, so that steam rises around the penis; this is done for about ten minutes and the process is repeated frequently. For sores in the male or female, water is used instead and the sore part placed over the hole and thus steamed. The root is boiled (evidently a European innovation, though originally heated stones may have been used to raise the temperature of the fluid) and the liquid drunk for stomachache and urinary trouble.

COMPOSITAE

Cassinia laevis R. Br. Yuilpo.

Senecio sp. Wildulda.

Xanthium spinosum L. Bathurst Burr. A "new-comer"; no name.

Inula gravecolens (L.) Desf. Stinkwort, introduced. A "new-comer"; no name.

Centaurea melitensis L. Star thistle. A "new-comer"; no name.

GASTROMYCETOUS FUNGI

Podaxon sp. Oordli-uta; not used.

Phellorinia strobilina (Kalchbr.) Kbr. et Cke. Ooliwoota, apparently a general name for this type of fungus, since the same name was supplied for *Podaxon*.

LICHENS

Encrusting lichens on rocks and mosses and trees. A-ta turra, not used.

ALGAE

A greenish filamentous alga which forms, when dried, an interlacing covering on the clay flakes of previously flooded land, is called Nang-ga (a term mean-

ing a woman's whiskers). The plant has been identified for us by the British Museum (Nat. Hist.) as *Nostoc commune* Vauch. var. *flagelliform* (Berk. et Curtis).

INTRODUCED SPECIES

The following introduced species (already noted) were called "new-comers" and our informants said they had no native names. The natives were deliberately tested out on these as a check on the reliability of the names given for native species. The introduced species comprised: Nettle, fat hen, pimpernel, *Datura stramonium*, tree tobacco (*Nicotiana glauca*), *Solanum nigrum*, Bathurst burr, and a star thistle.

WORDS FOR PARTS OF PLANTS, ETC.

Seeds from trees (pines, eucalypts, etc.), Yai-appi (wyappi). Fruit, yappi (cf., *Loranthus exocarpi*). Edible pulp, mai-i (cf., native peach). Dry wood of any kind, wurti nurtyu. Leaf, wurti alpi. Flower, ookalla. Root, wurti (wurti) avara. Seeds of Mitchell grass and other seeds generally (such as are ground and eaten), paua, vau-a. Gum from pines, *Xanthorrhoea* (yacca), *Myoporum* and various wattle trees, gnura. False sandalwood (*Myoporum*) gum was preferred for fixing stone axes to their handles.

Hale and Tindale in their "Observations on Aborigines of the Flinders Ranges, etc." (Mem. South. Austr. Mus., 3 (1), 1925, pp. 45-60), published a number of native names for the local flora (pp. 59-9?) as follows: Nardoo, *Marsilea quadrifolia* (= *M. Drummondii*), Ara; pine, *Callitris robusta*, Bimba; black oak, *Casuarina lepidophloia*, Ailko; needlebush, *Hakea leucoptera*, Barna; native peach, *Fusanus spicatus*, Wulti [the authors have confused the "peach" and sandalwood, the former being *Eucarya acuminata*, for which we received a similar name, Wurti]; buckbush [*Salsola kali*], Yilka; wattle, *Acacia* sp., Nguri; bullock bush, *Heterodendron oleifolium*, Minyara; red gum, *Eucalyptus rostrata*, Wera; box mallee, *Eucalyptus* sp. [*E. intertexta*] Yunda; tea tree, *Leptospermum scoparium* [probably a *Melaleuca*] Ora; Sandalwood, *Myoporum platycarpum*, Emburu; edible geranium, *Erodium cygnorum*, Ajinarupo; edible geranium, *Geranium pilosum*, Windu. The strong fibres of *Hibiscus Huegelii* were stated to have been prepared by macerating in water and then converted into twine for making nets for the capture of wallabies. Yam sticks, mungu wiri, used also as fighting sticks, were made from selected mallee wood (p. 48). Roots of *Erodium* were eaten. The dish made from the bark of the red gum is termed beki or wichi (p. 59). The information enclosed in square brackets has been added by us. Most of the native names given by these authors are similar to those obtained by us. The term Yunda for the box mallee, *Eucalyptus intertexta*, is apparently the origin of the name of a township, Yunta.

FLINDERSIAN LORICATES

By BERNARD C. COTTON, Conchologist, South Australian Museum,
and BENJAMIN J. WEEDING

Summary

In preparing this revision of the Flindersian Loricates we have been exceptionally fortunate in having access to the South Australian Museum's collection which contains the large collections made by the late Dr. W. G. Torr, Edwin Ashby and the late Sir Joseph Verco and W. L. May. In addition, the valuable material collected by enthusiastic members of the South Australian Malacological Society has been submitted to us for examination. Furthermore, we have, between us, personally collected around a large part of the South Australian coast, as far west as Fowler Bay. Every species has been examined by us personally except *Parachiton opiparus*, the one specimen of which is in the Australian Museum and the doubtful *Acanthochiton deliciosus* Thiele, in the Berlin Museum.

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PLATE VII

[Read 10 August 1939]

In preparing this revision of the Flindersian Loricates we have been exceptionally fortunate in having access to the South Australian Museum collection which contains the large collections made by the late Dr. W. G. Torr, Edwin Ashby and the late Sir Joseph Verco and W. L. May. In addition, the valuable material collected by enthusiastic members of the South Australian Malacological Society has been submitted to us for examination. Furthermore, we have, between us, personally collected around a large part of the South Australian coast, as far west as Fowler Bay. Every species has been examined by us personally except *Parachiton opiparus*, the one specimen of which is in the Australian Museum and the doubtful *Acanthochiton deliciosus* Thiele, in the Berlin Museum.

We have not used here many varietal and subspecific names, which are regarded by us as being of little value. The features upon which these are based are not constant and the forms are not confined to distinct geographical boundaries. On the other hand, names are given specific status when the differing features, however small, are constant and can be supported by a separate geographical location. All species in the different Faunal Regions should be allowed a certain amount of variation.

Several names are accepted which have been previously recorded as synonyms. These are, in most cases, the names of some of the rarer species, where lack of material makes it impossible at present to definitely confirm their exact status. It is better to stimulate research by recording them separately; their true status will never be ascertained if they are indiscriminately synonymised with other species.

The first list of South Australian Marine Mollusca was published by Angas in 1865. It contained the names of fourteen species of loricates, several of which have proved to be foreign. In Bednall's list, privately printed in 1876, two more species were added. Adcock's list, published in 1893, contained the names of twenty-one species, but eight of them are certainly not found here.

It was Bednall who, influenced by the publication of Pilsbry's Manual, encouraged by Professor Tate and aided by the collecting of Matthews, made the first attempt to record and classify every genuine South Australian species. In his historical monograph of 1897 thirty seven species were recorded, only one of which was misidentified.

This timely publication gave an added impetus to local collectors and, during the few years that followed, workers such as Bednall, Matthews, Torr, Ashby, Maughan, Saunders, Kimber and others rapidly added to our knowledge of the variety and number of Loricates found around our shores. So much so, that when Verco's list was printed in 1908, only eleven years later, fifty-two species were recorded, and Torr's paper, published four years later, included sixty-one species.

No list of South Australian Loricates has been published since Torr's Monograph of 1912, but Ashby's 1918 list of Australian species, credited this State with sixty-six species, and Iredales and Hull's Monograph of Australian Loricates lists sixty-seven species recorded from our coasts.

The Systematic List now presented is not confined to the political boundaries of South Australia but covers the whole of the coastline known as the Flindersian Region. This Region extends from Geraldton in Western Australia to Wilson's Promontory in Victoria, and includes the northern and western coasts of Tasmania.

Except for a few extra limital species, the Loricates of this Region form a distinctive group, quite different from those of the Peronian Region in the East and the Dampierian Region in the West.

Pilsbry, in 1892, classified the Loricates into three Superfamilies which he named: Eoplacophora, Mesoplacophora and Teleoplacophora. The wealth of material discovered since makes it advisable to raise the status of these Superfamilies to Orders and to add another Order to include a group widely represented in this Region.

Our classification proceeds from the simpler to the more complex forms and is based upon the study of the valves and girdles alone. The anatomical features do not seem to help in any marked way. Even the radula, which has proved so helpful in the classification of other Orders of Mollusca, varies too much, even in individuals of the same species, to be accepted as a reliable guide. This leaves only the differences in the shell and girdle by which the various forms can be grouped in a satisfactory manner.

Order EOPLACOPHORA

The Order Eoplacophora is characterised by the absence of insertion plates. It is regarded by some workers as the most primitive, representing the forms from which the more highly developed types have evolved. Other workers regard the members as degenerates from the Ischnochitonid group. It has only one Family in this Region, the

LEPIDOPLEURIDAE.

The members have small fragile shells with weak granulose sculpture. The insertion plates are absent and the sutural laminae small and widely separated, the few gills posteriorly situated. It contains two genera, *Terenochiton* and *Parachiton*, separated by the different girdle covering, shape of posterior valve and station.

Although a number of species is found in very deep water, many of the commonest are found in the Laminarian Zone, living in company with and under identical conditions as the *Ischnochitons*, making the theory of degeneration through environment difficult to accept. The group is probably degenerate from a different and older line than the *Ischnochitonidae*.

It should be noted that the simple forms of this Family do not show the varietal differences common in more elaborately sculptured forms, so that even small differences, when constant, must be regarded as of specific value.

Genus *TERENOCHITON*

Terenochiton niger Torr (D11686) is accepted as a distinct species from *T. mattheesianus* Bednall and has a black animal. The holotype of Bednall's species was, unfortunately, lost at sea, and it will never be known for certain whether the animal of the shell he described was red or black. The shells of the two forms show little difference, and *T. niger* Torr has been recorded as a synonym of *T. mattheesianus* Bednall. *T. niger* can be separated on sight from the red-footed form and, although the holotype was from Western Australia, the black-footed variety is found throughout the Region and it seems more reasonable to record it as *T. niger* Torr, than to refer to it as "the black-footed variety of *T. mattheesianus* Bednall."

The Peronian species *Terenochiton badius* Hedley and Hull was first taken at Port Jackson, New South Wales; a similar species was taken by Saunders at Cape Jervis in 1917 and was recorded as *T. badius* Hedley and Hull, 1909. Since then the species has been taken in a number of places as far west as Spencer Gulf. It is our smallest Loricata and in general appearance similar to *T. badius*. The Flindersian species, however, has distinct differences and we here describe it as:

Terenochiton iscus n. sp.

(Pl. vii, fig. 1)

Holotype—Gulf St. Vincent, S. Australia. D1232, S.A.M.

Shell small (5 x 3 mm.), oval, sub-carinated, sculptured with minute granules. Colour, buff to deep orange. Anterior valve, the lateral areas of the median valves and the post-mucronal area of the posterior valve, irregularly granulose. The jugal area is not separated from the pleural area. This central area of the median valves and the anti-mucronal area of the posterior valve, have the pustules arranged in rows. Generally, *T. iscus* has about 40 rows of pustules across the central area with eight pustules in the row.

The Peronian form has about fifty rows with twelve granules to the row. The larger and fewer granules of *T. iscus* give it a slightly coarser appearance.

Ashby has recorded this species as having a buff foot, but over thirty specimens collected by us in Spencer Gulf have had the typical bright red foot of *T. badius*.

The species is usually found attached to soft smooth sand-stone, well buried in sheltered pools. We have never found isolated specimens, they have been in groups or colonies, and the same colour as the rock to which they were attached.

Genus PARACHITON

Parachiton pelagicus Torr, 1912 (D11688) is one of the species now restored to the List. It has been recorded as a synonym of *P. columnarius* Hedley and May. It differs from that species in the angle of divergence, sculpture and shape of the posterior valve, and although paucity of material makes it impossible to decide the exact status of this species at present, enough differences have been recorded to warrant keeping the Flindersian separate from the Peronian species, until a longer series proves whether they are identical or not.

Among specimens dredged by the late Sir Joseph Verco near St. Francis Island was the large posterior valve of a distinctive Loricata, not yet recovered. It is certain that dredging around the Nuyts Archipelago will result in the discovery of the complete shell, and as it cannot be confused with any known species, we name it after its discoverer and describe it as:

Parachiton verconis n. sp.

(Pl. vii, fig. 2)

Holotype—St. Francis Island, S. Australia, D11689, S.A.M.

The posterior valve is 5 x 5 mm., colour a light buff. Anti-mucronal area exceptionally long and covered with about eighty rows of small coalescing granules, giving, where touching, a net-work appearance. Post-mucronal area very short and concave under the mucro, with short rows of coalescing granules and suggestions of growth ridges.

The nearest related species appears to be *P. puppis* Hull, a Peronian species found in a restricted area at Vaucluse, Watson Bay, N.S.W. The number of minutely grained striae in the Flindersian species is less than in the Peronian, giving it a slightly coarser appearance.

Order MESOPLACOPHORA

The Order Mesoplacophora has the insertion plates well developed, although small. The teeth are smooth and the girdles clothed with scales. By some workers it has been regarded as the basic group from which all the other Loricates have either developed or degenerated. Others regard it as the first step from the primitive to the more highly developed forms.

The Order is represented by two Families in this Region.

The first, the *Ischnochitonidae*, includes the simple unspecialized forms with small insertion plates and smooth teeth. The second, the *Cullistochitonidae*, while associated with the *Ischnochitonidae* by its radular features, is distinct in the peculiar scalloping of the teeth and elaborate sculpture of the tegmentum.

Genus ISCHNOCHITON

Iredale and Hull's identification of *Ischnochiton elongatus* Blainville and *Ischnochiton lineolatus* Blainville is accepted tentatively. In several publications, *I. elongatus* has been recorded as *I. lincolatus*, and *I. lineolatus* as *I. iredalei* Dup. Blainville's descriptions are meagre, but there is no detail in those descriptions which cannot be applied to those species for which the names are accepted. Also, most workers are familiar with Iredale and Hull's Monograph, and it will prevent further confusion to accept their nomenclature until more definite and independent information can be obtained.

The records of *Ischnochiton variegatus* H. Adams and Angas and *Ischnochiton atkinsoni* Iredale and May, have also been much confused. While there is no comparison between the small coarse unicoloured species from Tasmania and the larger, smoother, mottled species from Yorke Peninsula, it must be admitted that intermediate forms are not easily separated. The great variety of forms found in these species has led to the introduction of species and subspecies which cannot, at present, be recognised as valid.

Ischnochiton (Heterozona) properensis Ashby, 1920, is a valid species and not a local variant of *I. cariosus* Pilsbry, as has been recorded. *I. cariosus* has from four to six coarse nodulose rays on the lateral area, *I. properensis* has from eight to ten finer nodulose rays on the lateral area. In general appearance *I. properensis* is much smoother and darker coloured than *I. cariosus*.

Both *Ischnochiton (Heterozona) fruticosus* Gould, 1946, and *Ischnochiton (Haploplax) lentiginosus* Sowerby, 1840, must for the present be regarded as extra-limital species. The records for *lentiginosus* from South Australia are: three specimens from Yankalilla, Matthews' Collection, and one from Robe, Torr Collection, all now in the South Australian Museum.

Ischnochiton (Euporoplax) lewis Torr, 1912 (D11976), has been restored to our List. It has been confused with *Ischnochiton (Euretoplax) wilsoni* Sykes, 1896. Both species have been taken by us in Spencer Gulf and are quite distinct. *I. wilsoni* differs from *I. lewis* in its distinctive colour and larger and conspicuous striate girdle scales.

Ischnochiton (Chartoplax) purus Sykes, 1896, has been taken as far west as St. Francis Island by Dr. W. G. Torr. His specimen is undoubtedly this rare species.

Ovatoplax n. subg.

The subgenus *Ovatoplax* is here introduced for *Ischnochiton (Haploplax) mayi* Pilsbry 1895. This species has been placed in various genera - *Ischnochiton*, *Haploplax*, *Sypharochiton*—none of which are suitable.

Shell small to medium, ovate and of low elevation. Tegmentum weakly sculptured. Internally as in *Ischnochiton* but separated from that genus by its girdle scales, which are oval, weakly striate and loosely packed.

Sub-genotype—*Ischnochiton (Haploplax) mayi* Pilsbry, 1895.

Genus ISCHNORADSIA

We record all three forms of *Ischnoradsia* in the List. The strongly sculptured Peronian form (*Ischnoradsia australis* Sowerby) is not common in this region, but it has been taken as far west as the South-East coast of South Australia. The weak sculptured form (*I. evanida* Sowerby, 1840) is the common species in this region, while the smooth form (*I. novae-hollandiae* Reeve, 1847) is a variety of doubtful value. The three forms do not confine themselves to geographical boundaries.

Order Isoplacophora n. ord.

Shells small to large with large insertion plates and sutural laminae. Girdles large, fleshy and covered with spicules or corneous processes, rarely with scales.

This new Order has been introduced for a large group of Loricates which previously has been included in the Order *Mesoplacophora*. This must not be regarded merely as an artificial arrangement to divide the species into more evenly balanced groups, easier to key. It represents a distinct group of Loricates with probably no close phylogenetic association with either the preceding or following Orders. A number of fossil Loricates examined and classified by Ashby in recent years seem definitely to point to a separate line of evolution.

The Order includes four Families in the Flindersian Region—*Cryptoconchidae*, *Cryptoplacidae*, *Chorioplacidae* and the *Plaxiphoridae*.

Family CRYPTOCONCHIDAE

In the Family *Cryptoconchidae* the following alterations should be noted:

Genus ACANTHOCHITON

Acanthochiton (*Notoplax*) *rotnestensis* Ashby, 1929 (D12565), is placed in the genus *Craspedochiton* Shuttleworth, where it evidently belongs.

Acanthochiton deliciosus Thiele, 1911, has been included with considerable doubt; it is probably a very juvenile specimen of *Acanthochiton kimberi* Torr.

Acanthochiton bednalli variety *johnstoni* Ashby, 1923, we give full specific status. It has never been fully described or figured, so we here describe it.

ACANTHOCHITON JOHNSTONI Ashby, 1923

(Pl. vii, fig. 6)

Holotype—Woodman's Point, W. Australia, D12185; size, 16 x 7 mm.

Shell small to medium, elevation low. Colour white with black or green mottling. Anterior valve—irregularly pustulose. Pustules round and flat. Faint or no undulations. Median valve—lateropleural not separated; irregularly covered with flat round pustules. Jugal area—this area varies considerably, often narrow with six or seven weak striae, but sometimes with nine or ten weak striae. Girdle—large, fleshy and spiculose. Sutural tufts—conspicuous and silvery white.

Similar in general appearance to *A. bednalli*, but that species has ovate pustules, a wider jugum with more, deeper and broken striae and green sutural tufts. *A. johnstoni* can be recognised on sight by the round pustules and white sutural tufts.

Habitat—All around the Flindersian Region, but less common than *bednalli*.

Acanthochiton tatei Torr & Ashby (Neotype, D13732), 1898, takes the place of the Peronian *A. granostriatus* Pilsbry. The differences are small, but the species has the support of geographical locality for validity.

Acanthochiton verconis Torr & Ashby, 1898 (D12201), is returned to the List with considerable doubt. It has been recorded as conspecific with *A. wilsoni* Sykes. The differences may only be varietal but, until larger series prove them definitely identical, we prefer to leave them separate. *A. verconis* may be the weaker western end of the series or a deep water form of *A. wilsoni*.

Acanthochiton lachrymosus May & Torr, 1912, is accepted as the Flindersian representative of *A. cori* Pilsbry. It differs from the Peronian species in the wider jugal area, tear-drop pustules more confused and over-lapping and smaller and finer girdle spicules; these minor differences added to its geographical location supply our reason for recording it as a separate species.

Genus NOTOPLAX

In the *Notoplax* series, the records of *Notoplax speciosa* H. Adams, 1861, *Notoplax subspeciosa* Iredale & Hull, 1925, and *Notoplax spongialis* Ashby, 1923, have been confused.

Examination of the material in the South Australian Museum and consultation with the British Museum authorities has convinced us that all three are distinct species and that all three have been recorded as *N. speciosa* H. Adams.

Notoplax speciosa H. Adams, as described by Pilsbry, appears to be the large fleshy-girdled *Cryptoplax*-like animal with short thick spicules. It inhabits sponges and has been found in Tasmania and as far west as Streaky Bay. *Notoplax spongialis* is similar and also lives in sponges. It differs from *N. speciosa* in its felt-like girdle. This species is found in Tasmanian waters and as far west as Gulf St. Vincent. At the western end of the region a slight variation is found in the sculpture, and this form is now known as *Notoplax glauerti* Ashby, 1923.

Notoplax subspeciosa Iredale & Hull is an entirely different animal, which lives attached to rocks. In life the wide thin girdle spreads over the valves until only the jugum is exposed. All that is seen of the shell is eight short coloured lines drawn through a large oblong spiculose girdle. This species is not uncommon and is recorded as far west as Western Australia.

Notoplax rubrostrata Torr, 1912 (D13717), is not associated with the "*speciosa*" group. It is the Flindersian representative of *Notoplax costata* H. Adams & Angus. It differs from that species in being smaller and weaker sculptured. The ribbing of the anterior valve and lateropleural areas is nodulose

instead of continuous. The pustules of pleural area are less pronounced, and the post-mucronal area is less distinctly noduled. As with many other species it grows larger and more strongly sculptured in the colder waters of Tasmania, where it has been named *N. extra* Iredale & Hull. Both the rose- and plum-coloured specimens are found in South Australian waters.

Crocochiton n. gen.

The new genus *Crocochiton* is here introduced for the peculiar species *Acanthochiton crocodilus* Torr & Ashby.

Shell medium to large, elongate, wide, elevation low. Sculpture of tegmentum triangular pustules. Anterior valve with five slits, median valves one and posterior valve multi-slit. Girdle spongy and spiculose. Genotype—*Acanthochiton crocodilus* Torr & Ashby.

There does not appear to have been any other specimen of this rare species taken since Dr. Torr found two at Marino over thirty years ago, but valves found in shell sand along the western coast of Yorke Peninsula point to the existence of much larger varieties, if not new species.

Family CRYPTOPLACIDAE

In the Family *Cryptoplacidae*, one new species has been added to the list.

Genus CRYPTOPLAX

Ashby's holotype of *Cryptoplax striata* var. *westernensis*, 1923 (D10717), conforms so closely to the description of *Cryptoplax striata occidentalis* Iredale & Hull, 1925, that we are compelled to regard them as conspecific, Ashby's name having prior claim. As no adequate description or figure of either has been given, we add the following description:

CRYPTOPLAX WESTERNENSIS Ashby, 1923

(Pl. vii, fig. 4)

Shell medium. Valves almost as wide as long, their sides forming an obtuse angle making the beak very sharp. The tegmentum is sculptured with rows of large granules. Anterior valve—as broad as long. Median valves—close, flat and shield shaped. Posterior valve—mucro terminal. Girdle—similar to "*striata*."

This species is separated from *C. striata* Lamarck by its wide, flat, pointed median valves and sculpture of nodulose ridges. (In living examples the valves will probably be spaced differently.)

We are giving this form specific status because of its distinctive features and because it does not appear to blend with eastern varieties.

The holotype we figure is an old badly crumpled, eroded specimen.

Chorioplacidae n. fam.

The Family *Chorioplacidae* is here introduced for the unique genus *Chorioplax*. The known specimens are so entirely different from other species, that this seems

the wisest thing to do in the interest of accurate classification. Characters of the Family are:

Shells of medium size, elongate. Girdle thin and horny, covering the whole of the shell like a periostracum, except the apices of the valves which constitute the tegmentum. Articulamentum very large. Sutural laminac and sinus obsolete. Insertion plate large, unslit or slits obsolete. The whole shell transparent.

We list it directly after *Cryptoplax*, of which it may be a highly specialized form.

Chorioplax pattisoni Ashby, 1921, the unique specimen of which is now before us, is likely to remain rare, for a Loricata that dwells in the giant kelp forests in the turbulent depths of the Pacific Ocean, is fairly safe from even the most persistent and enthusiastic collector.

Family PLAXIPHORIDAE

Genus PONEROPLAX

Records of the species of *Poncroplax*, in the Family *Plaxiphoridae*, have been thoroughly confused. The species, which are emergent ones, are so abundant around the southern coast of Australia and Tasmania, that they were probably taken to Europe by every exploring vessel that visited these shores. Consequently, they were named by Blainville, Quoy and Gaimard, Haddon, Sowerby, H. Adams and Angas, besides Pilsbry and Thiele. With exceptionally variable species and such a large variety of names to choose from, the quandary of early workers can be understood.

We are following Iredale & Hull in recording the smooth form as *P. costata* Blainville and the wrinkled form as *P. albida* Blainville. We do this to prevent adding to the confusion and because we think this identity more probable. The recorded opinions of Thiele and Ashby, who both examined the holotypes in the Paris Museum, however, do not appear to coincide with Iredale's and Hull's.

Poncroplax conspersa H. Adams & Angas, 1864, is given full specific status. This highly sculptured form is easily distinguished by the two ribs on the lateral area. It is not confined to Port Lincoln but has been taken by us all around the South Australian coast, from the Bight to MacDonnell Bay.

Genus KOPIONELLA

The genus *Kopionella* we have also placed in the Family *Plaxiphoridae*. In general appearance, sculpture and girdle it appears to be more closely allied to that group than to the *Loricidae*.

Order TELEOPLACOPHORA

The Order *Telcoplacophora* contains all the most highly developed forms. It includes a variety of species which vary greatly in external and internal features but all have reached a high state of development. The characteristic feature of the Order is the grooved or pectinated teeth of the insertion plates. It contains

three Families, the *Loricidae*, *Lepidochitonidae* and *Chitonidae*. In the first Family one species is here described as new:

Family LORICIDAE

***Lorica elliotiae* n. sp.**

(Pl. vii, fig. 9)

Holotype—Rottnest Island, W. Australia, D11658, S.A.M.

Shell large; size, 71 x 34 mm. Altitude, 24 mm.; angle of divergence, 40. Semi-carinated, colour brown. Anterior valve—erect, curving forward at the top. The sculpture consists of about seventy finely granulated rays. Under the lens fine longitudinal ridges give a net-work appearance. Median valves—lateral area with about twelve fine ridges becoming weak and obsolete at the jugum, netted with fine longitudinal ridges. Pleural area with eight or nine finely granulated rays. Posterior valve—small, mucro posterior, recurved. Sculptured as lateral areas. Girdle—generic.

Habitat—Rottnest Island, W. Australia, and Corny Point, S. Australia. Collected by Mrs. L. A. Elliott.

Family LEPIDOCHITONIDAE

The Family *Lepidochitonidae* is included in this Order. The well-developed grooved insertion plates, the highly specialized girdle covering and the presence of eyes in some of the species, all denote an advanced group.

***Acutoplax* n. gen.**

A new genus is here introduced for the reception of several species:

Shell small to medium, elongate oval, elevated and carinated. Sculptured with longitudinal sulci on the pleural areas. Girdle of packed spicules. Well developed insertion plates with grooved teeth. End and median valves multi-slit. Genotype—*Callochiton mayi* Torr, 1912.

Differs from the South American genus *Icoplax* in the multi-slit insertion plates of the median valves and the sulci of the pleural area.

Family CHITONIDAE

In the Family *Chitonidae* we have accepted the generic name *Anthochiton* Thiele instead of *Rhyssoplax* Thiele, which has been used for our Australian species. The name *Rhyssoplax* has page priority over *Anthochiton*, but the Genotype of *Rhyssoplax*, *Chiton affinis* Issel in no way represents our shells. The genotype of *Anthochiton*, *Chiton tulipa* Quoy and Gaimard, is a South African species which approaches more nearly our own forms.

Genus MUCROSQUAMA

Two new species are here described in the genus *Mucrosquama*. The first was dredged by Sir J. Verco in Hardwicke Bay, and recorded by Torr in 1912 as

Chiton limans Sykes. The record was ignored and doubted because *C. limans* (= *Mucrosquama carnosa* Angas) is definitely a Peronian species. However, Verco was scrupulously careful regarding the locality of species he collected and the locality has never been dredged since. This, added to the fact that the specimen has a number of distinct differences from the Peronian specimens, induces us to describe it as:

***Mucrosquama nielseni* n. sp.**

(Pl. vii, fig. 8)

Holotype—Hardwicke Bay, S. Australia, D13720, S.A.M.

Shell of medium size, elevated and carinated. Colour pale ochreous yellow with light and dark brown blotches on some of the valves. Anterior valve—erect, with ten weak pustulose rays and a few pustules in the interstices. Median valves—lateral areas with two to four pustulose rays. Pustules of the posterior edge projecting as teeth. Pleural area with from five to eight ridges crossing the area and a few weak ridges partly crossing it and fading out towards the jugum, leaving a large smooth triangular jugal area. Posterior valve—antimucronal area with a few weak ridges. Postmucronal area with ten rays of two or three pustules. Girdle—generic. Microscopically striate.

Mucrosquama nielseni is undoubtedly the Flindersian representative of *M. carnosa* Angas. In *M. carnosa* most of the ridges cross the pleural area, in *M. nielseni* half of the ridges cross that area. The two species bear the similar relationship to each other, as *Anthochiton jugosus* does to *Anthochiton diaphorus*. We feel confident that further dredgings will produce more specimens.

The second species was dredged in Spencer Gulf in March, 1938, by Mr. K. Sheard, from the Fisheries launch "Whyalla." We describe and figure it as:

***Mucrosquama sheardi* n. sp.**

Holotype—Dredged Spencer Gulf, S. Australia, D13721, S.A.M.

Shell of medium size (25 x 10 mm.), elevated and carinated, colour cream blotched with dark green and brown. Anterior valve—sculptured with eleven rows of irregular oval and round nodules, about nine nodules in a row, diminishing in size towards the apex. Median valve—lateral area with two rows of strong round or oval nodules, about ten in a row, diminishing in size towards the jugum. Pleural area with about fifteen fine grooves. Posterior valve—mucro anti-median. Antimucronal area grooved as pleural area. Post-mucronal area with twelve short radial rows of small nodules, about five or six in a row. Jugal area—weakly grooved, with grooves fading out towards the apex leaving apex smooth. Girdle—clothed with strongly striate and mucronate scales.

This species is closely allied to *Mucrosquama verconis* Torr & Ashby, 1898 (D12380), but differs from that species in colour and sculpture. The nodules of the lateral areas, anterior and posterior valves, are smaller, rounder and more

separated than the wide, oval interlapping nodules of *M. verconis*. The fine grooves or ridges of the pleural areas are less oblique than those of *M. verconis*, being almost straight across. The predominating colour of *M. verconis* is pink, while that of *M. sheardi* is green.

Genus SYPHAROCHITON

Sypharochiton maugeanus Iredale & May, 1916, is included in the List. This species is the Tasmanian representative of the New Zealand *Sypharochiton pelliserpentis* Quoy & Gaimard. It differs so little from that species that its validity will always be questioned. We include it because its minor differences are supported by geographical grounds.

Genus ONITHOCHITON

On the above grounds we have also allowed *Onithochiton occidentalis* Ashby, 1929, specific status. Individual specimens of *Onithochiton quercinus* Gould, 1846, from the Eastern States, will always be found that are difficult, if not impossible to separate from the western species. However, the western forms average out much larger and smoother than the eastern forms, and this, with the minor differences cited by Ashby and the geographical locality, influenced us in giving it full specific status.

KEYS TO THE LORICATES OF THE FLINDERSIAN REGION

Key to Orders

- | | | | | |
|---|----|----|----|----------------|
| a. Insertion plates absent or almost obsolete | .. | .. | .. | EOPLACOPHORA |
| aa. Insertion plates developed | | | | |
| b. Teeth smooth | | | | |
| c. Insertion plates small, girdles clothed with scales | .. | .. | .. | MESOPLACOPHORA |
| cc. Insertion plates large, girdles leathery, spiculose, or with corneous processes, rarely with scales | .. | .. | .. | ISOPLACOPHORA |
| bb. Teeth grooved, striate or pectinate | .. | .. | .. | TELEPLACOPHORA |

Order EOPLACOPHORA

with one Family in this Region

Family LEPIDOPLEURIDAE

Key to Genera

- | | | | | |
|--|----|----|----|----------------------|
| a. Girdles with scales, posterior valve normal | .. | .. | .. | <i>Terenoichiton</i> |
| aa. Girdles spiculose, posterior valve abnormally long | .. | .. | .. | <i>Parachiton</i> |

Genus TERENOCHITON

Key to Species

- | | | | | | |
|---|----|----|----|----|------------------------|
| a. Anterior valve with regular granulose rays | | | | | |
| b. Lateral area even | | | | | |
| c. Animal red | .. | .. | .. | .. | <i>matthewsonianus</i> |
| cc. Animal black | .. | .. | .. | .. | <i>niger</i> |
| bb. Lateral areas corrugated | .. | .. | .. | .. | <i>liratus</i> |
| aa. Anterior valve irregularly granulose | | | | | |
| d. Shell sub-carinated | .. | .. | .. | .. | <i>iscus</i> |
| dd. Shell strongly carinated | .. | .. | .. | .. | <i>glauerti</i> |

Genus PARACHITON

Key to Species

- a. Sculpture granulose
 - b. Posterior valve normal, mucro not extremely posterior
 - c. Shell highly elevated, lateral areas smooth *pelagicus*
 - cc. Shell of normal elevation, lateral areas corrugated .. *collusor*
 - bb. Posterior valve abnormally large, mucro extremely posterior *verconis*
- aa. Sculpture matt, not granulose *opiparus*

Order MESOPLACOPHORA

Key to Families

- a. Teeth not scalloped ISCHNOCHITONIDAE
- aa. Teeth scalloped CALLISTOCHITONIDAE

Family ISCHNOCHITONIDAE

Key to Genera

- a. Insertion plates of median valves unslit, or slits obsolete .. *Sublerenchiton*
- aa. Insertion plates of median valves slit
 - b. Insertion plates with one slit *Ischnochiton*
 - bb. Insertion plates multi-slit
 - c. Girdle scales minute, shells polished *Stenochiton*
 - cc. Girdle scales large, shells sculptured *Ischnoradsia*

Genus SUBTERENOCHITON

Key to Species

- a. Sculpture weak, irregularly granulose *gabrielii*
- aa. Sculpture strong, granules in rows *bednalli*

Genus ISCHNOCHITON

Key to Subgenera

- a. Lateral area radially sculptured
 - b. Girdle scales medium size, oval and striate *Ischnochiton*
 - bb. Girdle scales of various size and shape *Heterozona*
 - c. Girdle scales not mucronate
 - d. Scales microscopic and closely packed *Autochiton*
 - dd. Scales medium size, loosely packed *Ovatoplax*
 - cc. Girdle scales mucronate *Strigichiton*
- aa. Lateral areas smooth
 - e. Girdle scales convex and glossy *Haploplax*
 - cc. Girdle scales not convex and glossy
 - f. Girdle scales oval and striate
 - g. Girdle scales conspicuously striate *Eurctoplax*
 - gg. Girdle scales microscopically striate *Euforoplax*
 - ff. Girdle scales flat and smooth *Chartoplax*

Genus ISCHNOCHITON

Key to Species

- a. Anterior valve with medium to strong radial ribs
 - b. Girdle scales large *milligani*
 - bb. Girdle scales medium or small
 - c. Anterior valve nodulosely ribbed
 - d. Girdle scales medium, striae of pleural area zig-zag .. *lincolatus*
 - dd. Girdle scales small, striae of pleural area not zig-zag
 - e. Pleural area finely granulose *variegatus*
 - ee. Pleural area coarsely granulose *atkinsoni*
 - cc. Anterior valve not nodulosely ribbed
 - f. Pleural area coarsely pustulose and edge of lateral area not toothed *pilsbryi*
 - ff. Pleural area not coarsely pustulose but edge of lateral area toothed
 - g. Striae of pleural area wrinkled *ptychius*
 - gg. Striae of pleural area not wrinkled *tateanus*

- aa. Anterior valve not radially ribbed or ribs weak and obsolete
 h. Ribs weak and obsolete
 i. Pleural area strongly ridged *falcatus*
 ii. Pleural area not ridged *elongatus*
 hh. Anterior valve not ribbed, sculptured with
 separate pustules *contractus*

Subgenus HETEROZONA

Key to Species

- a. Lateral areas strongly nodulosely ribbed
 b. Ribs divaricating *fruticosus*
 bb. Ribs not divaricating
 c. Girdle with intermingled large scales *cariosus*
 cc. Girdle with no intermingled large scales *subviridis*
 aa. Lateral areas weakly nodulosely ribbed *properensis*

Subgenus AUTOCHITON

- One species only *torri*

Subgenus OVATOPLAX

- One species only *mayi*

Subgenus STRIGICHITON

- One species only *terconis*

Subgenus HAPLOPLAX

Key to Species

- a. Girdle scales of various size
 b. Surface of shell glossy, colour variable *smaragdinus*
 bb. Surface of shell matt, colour distinctive *resplendens*
 aa. Girdle scales of equal size
 c. Shell broadly ovate, elevation low, scales large *lentiginosus*
 cc. Shell elongate oval, elevation medium, scales small *thomasi*

Subgenus EUPOROPLAX

Key to Species

- a. Shell small, elevated, elongated oval *virgatus*
 aa. Shell medium in size and elevation, ovate *levis*

Subgenus EURETOPLAX

- One species only *wilsoni*

Subgenus CHARTOPLAX

- One species only *purus*

Genus STENOCHITON

Key to Species

- a. Anterior valve longer than wide
 b. Shell seven times long as wide, colour brownish *longicymba*
 bb. Shell three or four times long as wide
 c. Shell low, girdle not curling under *pilsbryanus*
 cc. Shell elevated, girdle curling under *cymodoccalis*
 aa. Anterior valve wider than long *pallens*

Genus ISCHNORADIA

Key to Species

- a. Pleural area sulcated
 b. Sulcations continuous and strong *australis*
 bb. Sulcations short and weak *cranida*
 aa. Pleural area not sulcated *novae hollandia*

Family CALLISTOCHITONIDAE

Key to Genera

- a. Sutural laminae separated *Callistelasma*
 aa. Sutural laminae continuous *Callistassecla*

Genus CALLISTELASMA

One species only *meridionalis*

Genus CALLISTASSECLA

One species only *mawlei*

Order ISOPLACOPHORA

Key to Families

- a. Anterior valve with less than eight slits
 - b. Tegmentum of valves imbricating CRYPTOCONCHIDAE
 - bb. Tegmentum of valves not imbricating
 - c. Girdle large and fleshy CRYPTOPLACIDAE
 - cc. Girdle reduced to a thin skin CHORIPLACIDAE
- aa. Anterior valve with eight or more slits PLAXIPHORIDAE

Family CRYPTOCONCHIDAE

Key to Genera

- a. Sculpture pustulose
 - b. Girdle finely scaly
 - c. Girdle anteriorly produced *Craspedochiton*
 - cc. Girdle normal *Craspedoplax*
 - bb. Girdle not scaly
 - d. Insertion plates and sutural laminae normal size
 - e. Posterior insertion plate directed backwards *Meturoplax*
 - ee. Posterior insertion plate normal *Acanthochiton*
 - dd. Insertion plates and sutural laminae large and wing-shaped *Notoplax*
- aa. Sculpture not pustulose
 - f. Sculpture mostly linear *Bassethullia*
 - ff. Sculpture triangular *Crocichiton*

Genus CRASPEDOCHITON

One species only *rotnnestensis*

Genus CRASPEDOPLAX

Key to Species

- a. Sculptured with fine granules, common in shallow water *variabilis*
- aa. Sculptured with coarser granules, rare and dredged *cornuta*

Genus METUROPLAX

One species only *retrojecta*

Genus ACANTHOCHITON

Key to Species

- a. Girdle leathery
 - b. Pustulose sculpture irregular
 - c. Pustules of various sizes
 - d. Jugal area granulose *kimberi*
 - dd. Jugal area pitted *deliciosus*
 - cc. Pustules of similar size *sucurii*
 - bb. Pustulose sculpture in regular rows *pilsbryi*
- aa. Girdle spiculose
 - c. Girdle of medium size, sutural tufts conspicuous
 - f. Jugal area finely pustulose *gatliffi*
 - ff. Jugal area not pustulose
 - g. Jugum grooved *bednalli*
 - gg. Jugum not grooved but lined
 - h. Pustules round and flat *johnstoni*
 - hh. Pustules elliptical *tatei*
 - ee. Girdle large, sutural tufts not conspicuous
 - i. Pustulose sculpture fine
 - j. Jugal area narrow, pustules crowded *wilsoni*
 - jj. Jugum wider, pustules less crowded *zerconis*
 - ii. Pustulose sculpture coarse, tear shaped *lachrymosus*

Genus NOTOPLAX

Key to Species

- a. Girdle thickly spiculose, ribs not prominent
 - b. Girdle coarsely spiculose
 - c. Girdle large and fleshy, spicules short and thick *speciosa*
 - cc. Girdle wide and thin spicules longer *subspeciosa*
 - bb. Girdle finely spiculose
 - d. Post-mucronal area not ribbed *spongialis*
 - dd. Post-mucronal area ribbed *glauerti*
- aa. Girdle leathery with spinelets, ribs prominent.
 - e. With one nodulose rib on the median valves *rubrostrata*
 - ee. With two nodulose ribs on the median valves *subviridis*

Genus BASSETHULLIA

Key to Species

- a. Pleural area sculptured *matthewsi*
- aa. Pleural area smooth *glypta*

Genus CROCOCHITON

- One species only *crocodilus*

Family CRYPTOPLACIDAE

- One genus only *Cryptoplax*

Genus CRYPTOPLAX

Key to Species

- a. Girdle coarsely spiculose
 - b. Sculptured with crumpled or wavy ridges *striata*
 - bb. Sculptured with nodulose ridges *westernensis*
- aa. Girdle finely spiculose *iredalei*

Family CHORIPLACIDAE

- One genus only *Choriplax*

Genus CHORIPLAX

- One species only *pattisoni*

Family PLAXIPHORIDAE

Key to Genera

- a. Lateral area defined by smooth or wrinkled ridges, girdle with corneous processes only, posterior valve not recurved *Poneroplax*
- aa. Lateral area defined by nodulose ridges, girdle with corneous processes and oar headed spicules, posterior valve recurved *Kopionella*

Genus PONEROPLAX

Key to Species

- a. Pleural area not concentrically wrinkled *costata*
- aa. Pleural area concentrically wrinkled
 - b. Lateral area with one radial rib *albida*
 - bb. Lateral area with two radial ribs *conspecta*

Genus KOPIONELLA

- One species only *matthewsi*

Order TELEOPLACOPHORA

Key to Families

- a. Teeth not finely pectinate
 - b. No insertion plate in posterior valve LORICIDAE
 - bb. Insertion plates in all valves LEPIDOCHITONIDAE
- aa. Teeth finely pectinated CHITONIDAE

Family LORICIDAE

Key to Genera

- a. Anterior valve abnormally large *Loricella*
- aa. Anterior valve of normal size *Lorica*

One species only Genus LORICELLA *angasi*

Genus LORICA

Key to Species

a. Elevation medium, shell broad *cimolia*
 aa. Elevation high, shell narrow *elliottae*

Family LEPIDOCITONIDAE

Key to Genera

a. Shells not sculptured
 b. Shells large with leathery girdle *Eudoxoplax*
 bb. Shells small or medium, packed spiculate girdle *Paricoplax*
 aa. Shells with pleural area grooved *Acutoplax*

Genus EUDOXOPLAX

One species only *inornata*

Genus PARICOPLAX

One species only *crocina*

Genus ACUTOPLAX

Key to Species

a. Most sulci extending across the pleural area *mayi*
 aa. Most sulci not extending across the pleural area
 b. Sulci extending half-way across the pleural area *rufa*
 bb. Sulci extending one-fourth of the pleural area *klemi*

Family CHITONIDAE

Key to Genera

a. Girdles scaly
 b. Scales tightly imbricating
 c. Apices of scales round *Anthochiton*
 cc. Apices of scales pointed *Mucrosquama*
 bb. Scales large and loose
 d. Posterior valve with insertion plate *Sypharochiton*
 dd. Posterior valve callused *Clavaziriona*
 aa. Girdles not scaly
 e. Girdle with calcareous spines *Acanthozostera*
 ee. Girdle not spinose
 f. Girdle fleshy with microscopic scales *Onithella*
 ff. Girdle fleshy with fine spicules
 g. Posterior valve callused *Onithochiton*
 gg. Posterior valve with insertion plate *Lucilina*

Genus ANTHOCHITON

Key to Species

a. Anterior valve smooth
 b. Scales small and oval *oruktu*
 bb. Scales large and sub-oval
 c. Pleural sculpture weak *torrianus*
 cc. Pleural sculpture strong *diaphorus*
 aa. Anterior valve ribbed
 d. Lateral ribs non-nodulose
 e. Interstices of lateral ribs not pitted *calliozonus*
 ee. Interstices of lateral ribs pitted
 f. Radial sculpture strong *bednalli*
 ff. Radial sculpture weak *croptandus*
 dd. Lateral ribs nodulose
 g. Longitudinal sculpture strong *tricastalis*
 gg. Longitudinal sculpture weak *geraldtonensis*

Genus MUCROSQUAMA

Key to Species

- a. Anterior valve ribbed *nielsenii*
 aa. Anterior valve not ribbed
 b. Sculpture of lateral areas round separate nodules *sheardi*
 bb. Sculpture of lateral areas oval interlapping nodules *verconis*

Genus SYPHAROCHITON

- One species only *maugeanus*

Genus CLAVARIZONA

- One species only *hirtosa*

Genus ACANTHOZOSTERA

- One species only *gemmata*

Genus ONITHELLA

- One species only *ashbyi*

Genus ONITHOCHITON

- One species only *occidentalis*

Genus LUCILINA

- One species only *hulliana*

A SYSTEMATIC LIST OF THE LORICATES OF THE FLINDERSIAN REGION

Phylum MOLLUSCA

Class LORICATA

Order MESOPLACOPHORA

LEPIDOPLEURIDAE

- TERENOCHITON* Iredale, 1914 (*subtropicalis* Iredale)—*matthewsianus* Bednall, 1906, Gulf St. Vincent, South Australia (Neotype, D13734); *niger* Torr, 1911, Hopetoun, Western Australia (D11686); *liratus* H. Adams & Angas, 1864, Yorke Peninsula, South Australia (Neotype, D13735); *iscus* n.sp., Gulf St. Vincent, South Australia (D1232); *glauerti* Ashby, 1928, Rottnest Island, Western Australia.
- PARACHITON* Thiele, 1909 (*acuminatus* Thiele)—*pelagicus* Torr, 1912, off Cape Jaffa, South Australia (D11688); *collusor* Iredale & Hull, 1925, Gulf St. Vincent, South Australia (D11288); *verconis* n.sp., off St. Francis Island, South Australia (D11689); *opiparus* Iredale & Hull, 1926, off Cape Wiles, South Australia.

Order MESOPLACOPHORA

ISCHNOCIIITONIDAE

- SUBTERENOCHITON* Iredale & Hull, 1924 (*gabrielii* Hull)—*gabrielii* Hull, 1912, Western Port, Victoria; *bednalli* Torr, 1912, St. Francis Island, South Australia (D11792).
- ISCHNOCIIITON* Gray, 1847 (*textilis* Gray)—*milligani* Iredale & May, 1916, Port Arthur, Tasmania; *lincolatus* Blainville, 1826, Ile King, Bass Strait; *variegatus* H. Adams & Angas, 1864, Yorke Peninsula, South Australia (Neotype, D13736); *atkinsoni* Iredale & May, 1916, Sulphur Creek, North-west Tasmania; *pilsbryi* Bednall, 1897, Sultana Bay, South Australia (Neotype, D11766); *ptychius* Pilsbry, 1894, Gulf St. Vincent, South Australia; *tutanus* Bednall, 1897, Sultana Bay, South Australia (Neotype, D13738); *falcatus* Hull, 1912, Western Port, Victoria; *elongatus* Blainville, 1825, New Holland; *contractus* Reeves, 1847, New Zealand, (error) South Australia.
- s.g. *HETEROZONA* Dall, 1878 (*cariosa* Dall)—*fruticosus* Gould, 1846, New South Wales; *cariosus* Dall, 1878, Australia; *subviridis* Iredale & May, 1916, Port Arthur, Tasmania; *propercusis* Ashby, 1920, Proper Bay, Spencer Gulf, South Australia (D11896).

- s.g. *AUTOCHITON* Iredale & Hull, 1924 (*torri* Iredale & May)—*torri* Iredale and May, 1916, Bass Strait, Tasmania.
- s.g. *OVATOPLEX* n. sg. (*mayi* Pilsbry)—*mayi* Pilsbry, 1895, Eagle Hawk Neck, East Tasmania.
- s.g. *STRIGICHITON* Hull, 1923 (*verconis* Torr)—*verconis*, 1911, Ellenbrook, Western Australia (D12868).
- s.g. *HAPLOPLAX* Pilsbry, 1894 (*smaragdina* Pilsbry)—*smaragdinus* Angas, 1864, Port Jackson, New South Wales; *resplendens* Bednall & Matthew, 1906, Gulf St. Vincent, South Australia (Neotype, P13739); *lentiginosus* Sowerby, 1840, Australia; *thomasi* Bednall, 1897, Marino, South Australia (Neotype, D13737).
- s.g. *EUTROPLAX* Iredale & Hull, 1924 (*virgatus* Reeve)—*virgatus* Reeve, 1847, Port Lincoln, South Australia; *levis* Torr, 1912, Edithburgh, South Australia.
- s.g. *ECRETOPLEX* Iredale & Hull, 1924 (*wilsoni* Sykes)—*wilsoni* Sykes, 1896, Port Phillip, Victoria.
- s.g. *CHARTOPLEX* Iredale & Hull, 1925 (*purus*)—*purus* Sykes, 1896, Port Phillip, Victoria.
- STENOCHITON* H. Adams & Angas, 1864 (*juloides* H. Adams & Angas)—*longicymba* Blainville, 1825, Kangaroo Island, South Australia; *pilsbryanus* Bednall, 1897, Troubridge Shoal, South Australia; *cymodocealis* Ashby, 1918, Marino, South Australia (D981); *pallens* Ashby, 1900, Gulf St. Vincent, South Australia (D978).
- ISCHINORADSLA* Shuttleworth, 1853 (*australis* Sowerby)—*australis* Sowerby, 1840, Australia; *exanida* Sowerby, 1840, New Holland; *nozac-hollandiae* Reeve, 1847, New Holland.

CALLISTOCHITONIDAE

- CALLISTELASMA* Iredale & Hull, 1925 (*antiquus* Reeve)—*meridionalis* Ashby, 1919, Marino, South Australia (D13716).
- CALLISTASSECLA* Iredale & Hull, 1925 (*maulei* Iredale & May)—*maulei* Iredale & May, 1916, Port Arthur, Tasmania.

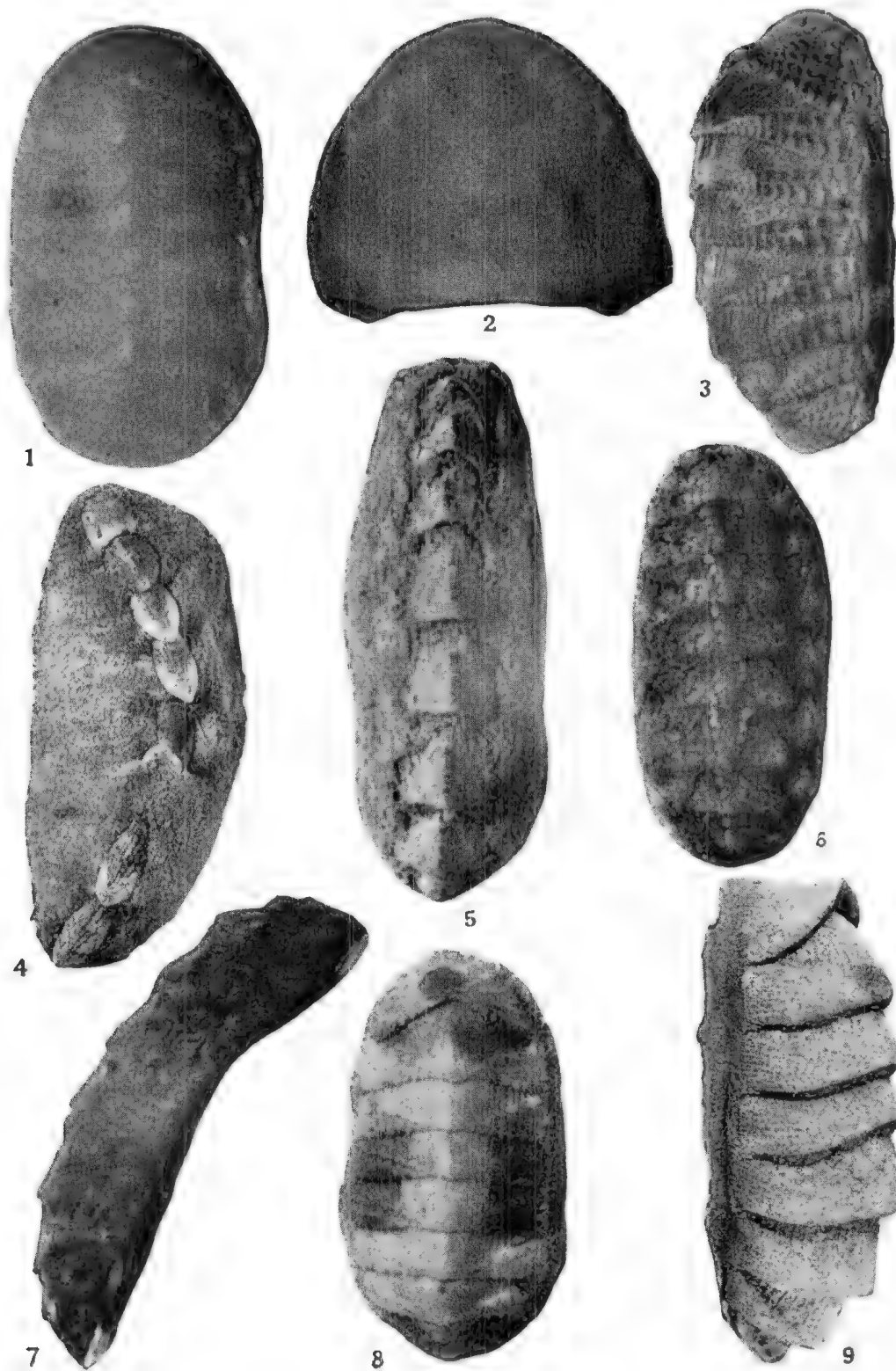
Order ISOPLACOPHORA

CRYPTOCONCHIDAE

- CRASPEDOCHITON* Shuttleworth, 1853 (*laqueatus* Sowerby) *rotnnestensis* Ashby, 1929, Bathurst Point, Western Australia (D12565).
- CRASPEDOPLAX* Iredale & Hull, 1925 (*variabilis* H. Adams & Angas)—*variabilis* H. Adams & Angas, 1864, Yorke Peninsula, South Australia (Neotype, D13740); *cornuta* Torr & Ashby, 1898, Marino, South Australia (D12188).
- METUROPLAX* Pilsbry, 1894 (*retrojecta* Pilsbry)—*retrojecta* Pilsbry, 1894, Port Jackson, New South Wales.
- ACANTHOCHITON* Gray, 1821 (*fascicularis* Linn.)—*kimberi* Torr, 1912, Aldinga, South Australia (Neotype D13758); *deliciasus* Thiele, 1911, Bunbury, South Western Australia; *sucurii* Blainville, 1825, King George Sound, South Western Australia; *pilsbryi* Sykes, 1898, Port Phillip, Victoria; *gatliffi* Ashby, 1918, Port Lincoln, South Australia (D12189); *bednalli* Pilsbry, 1894, Gulf St. Vincent, South Australia; *johnstoni* Ashby, 1923, Carnarvon, Western Australia (D12185); *latei* Torr & Ashby, 1898, Encounter Bay, South Australia; *wilsoni* Sykes, 1896, Port Phillip, Victoria; *verconis* Torr & Ashby, 1898, Gulf St. Vincent, South Australia (D12201) *lachrymosus* May & Torr, 1912, Frederick Henry Bay, Tasmania.
- NOTOPLAX* H. Adams, 1861 (*speciosa* H. Adams)—*speciosa* H. Adams, 1861, Tasmania; *subspeciosa* Iredale & Hull, 1926, Port Arthur, Tasmania; *spongialis* Ashby, 1923, D'Entrecasteaux Channel, South Tasmania (D13733); *glauerti* Ashby, 1923, Cottesloe, Western Australia; *rubrostrata* Torr, 1912, St. Francis Island, South Australia (D13717); *subviridis* Torr, 1911, Albany, Western Australia (D12872).
- BASSETHULLIA* Pilsbry, 1928 (*matthewsi* Pilsbry) *matthewsi* Pilsbry, 1894, Yorke Peninsula, South Australia (Neotype, D1374); *glypta* Sykes, 1896, Port Phillip, Victoria.
- CROCOCHITON* n. gen. (*crocodilus* Torr & Ashby)—*crocodilus* Torr & Ashby, 1898, Marino, South Australia (D12137).

CRYPTOPLACIDAE

- CRYPTOPLAX* Blainville, 1818 (*larvaciformis* Burrow)—*striata* Lamarck, 1819, Kangaroo Island, South Australia; *westernensis* Ashby, 1923, Rottnest Island, Western Australia (D10717); *iredalei* Ashby, 1923, Port Lincoln, South Australia (D12306).



CHORIPLACIDAE

CHORIPLAX Pilsbry, 1894 (*grayi* H. Adams & Angas)—*pattisoni* Ashby, 1921, Cape Banks, South Australia.

PLAXIPHORIDAE

PONEROPLAX Iredale, 1914 (*costata* Blainville)—*costata* Blainville, 1825, King George Sound, Western Australia; *albida* Blainville, 1825, Ile King, Bass Strait; *conspersa* H. Adams & Angas, 1854, Port Lincoln, South Australia.

KOPIONELLA Ashby, 1919 (*matthewesi* Iredale)—*matthewesi* Iredale, 1910, Sultana Bay, South Australia.

Order TELEOPLACOPHORA

LORICIDAE

LORICELLA Pilsbry, 1893 (*angasi* H. Adams & Angas)—*angasi* H. Adams & Angas, 1864, Rapid Bay, South Australia.

LORICA H. & A. Adams, 1852 (*cimolius* Reeve)—*cimolia* Reeve, 1847, Australia; *elliottae* n. sp., Rottnest Island, Western Australia (D11658).

LEPIDOCHITONIDAE

EUDOXOPLAX Iredale & May, 1916 (*inornata* Tenison-Woods)—*inornata* Tenison-Woods, 1881, North Tasmania.

PARICOPLAX Iredale & Hull, 1929 (*crocina* Reeve)—*crocina* Reeve, 1847, probably New South Wales.

ACUTOPLAX n. gen. (*mayi* Torr)—*mayi* Torr, 1912, Stanley, North-west Tasmania (Neotype, D10679); *rufa* Ashby, 1900, Gulf St. Vincent, South Australia (D11700); *klemi* Ashby, 1926, Daly Head, South Australia (D11703).

CHITONIDAE

ANTHOCHITON Thiele, 1893 (*tulipa* Quoy & Gaimard)—*oruktus* Maughan, 1900, MacDonnell Bay, South Australia (D1489); *torriana* Hedley & Hull, 1910, Kangaroo Island, South Australia; *diaphorus* Iredale & May, 1916, Norfolk Bay, Tasmania; *calliozonus* Pilsbry, 1894, Gulf St. Vincent, South Australia; *bednalli* Pilsbry, 1895, Yorke Peninsula, South Australia (D13742); *exoptandus* Bednall, 1897, Gulf St. Vincent, South Australia (Neotype, D13744); *tricostalis* Pilsbry, 1894, Gulf St. Vincent, South Australia; *geraldtonensis* Ashby, 1921, Geraldton, Western Australia (D10709).

MUCROSQUAMA Iredale & Hull, 1926 (*carcosa* Angas)—*nielsenii* n. sp., Hardwicke Bay, South Australia (D13720); *sheardi* n. sp., Spencer Gulf, South Australia (D13721); *verconis* Torr & Ashby, 1898, Gulf St. Vincent, South Australia (D12380).

SYMPHAROCHITON Thiele, 1893 (*pelliserpentis* Quoy & Gaimard)—*maugaeus* Iredale and May, 1916, Port Arthur, Tasmania.

CLAVARIZONA Hull, 1923 (*hirtosa* Blainville)—*hirtosa* Blainville, 1835, King George Sound, Western Australia.

ACANTHOZOSTERA Iredale & Hull, 1926 (*gemmatus* Blainville)—*gemmata* Blainville, 1825, New Holland.

ONITHIELLA Mackay, 1933 (*helenae* Mackay)—*ashbyi* Bednall & Matthew, 1906, Port Willunga, South Australia (Neotype, D13745).

ONITHOCHITON Gray, 1847 (*undulatus* Q. et G.—*neglectus* Rochebrune)—*occidentalis* Ashby, 1929, Dongarra, Western Australia (D12627).

LUCILINA Dall, 1881 (*confossus* Gould)—*hulliana* Torr, 1911, Ellenbrook, Western Australia (D12873).

EXPLANATION OF PLATE VII

Fig. 1 *Terenochiton iscus* sp. nov.

Fig. 2 *Parachiton verconis* sp. nov.

Fig. 3 *Mucrosquama sheardi* sp. nov.

Fig. 4 *Cryptoplax westernensis* sp. nov.

Fig. 5 *Notoplax speciosa* H. Adams

Fig. 6 *Acanthochiton johnstoni* Ashby

Fig. 7 *Notoplax spongialis* Ashby

Fig. 8 *Mucrosquama nielsenii* sp. nov.

Fig. 9 *Lorica elliotae* sp. nov.

LARVAL TREMATODES FROM AUSTRALIAN FRESHWATER MOLLUSCS PART VI

By T. H. JOHNSTON and L. MADELINE ANGEL, University of Adelaide

Summary

Cercaria clelandae n. sp.

We have obtained this echinostome cercaria only from *Planorbis isingi* Cotton from Tailem Bend, finding it in one of eight snails in December, 1938, in none of 177 in early February, in three of 60 ten days later, in two of 114 in March, and in 12 of 2,129 in May, 1939 - a total of 18 infected amongst 2,488 examined during summer and autumn. The average of infected snails was one in 138.

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The organisms are comparatively large and easily visible to the unaided eye. They are negatively phototropic and tend to remain near the bottom of the tube, swimming upwards occasionally. They exhibit the usual echinostome creeping movement, the body altering from an almost spherical form when contracted to become long and narrow. Cercariae were measured after fixing by adding boiling 10% formalin to an equal volume of water containing them. In fixed specimens the body is curved and bent to make nearly a right angle with the tail. Body length (based on 20 cercariae) 230-290 μ ; breadth about 100 μ , range 89-130 μ ; average transverse diameter of the oral sucker (measured under cover glass) 46 μ , that of the acetabulum 61 μ , the ratio of these two diameters being about 3:4. The tail in living extended cercariae is a little longer than the body, very occasionally nearly twice as long; but in fixed material the length is 320-460 μ and the breadth 35-50 μ . There is no tail fin.

The collar is not very prominent. Including the four spines at each corner, there are 45, 37 being arranged in two rows uninterrupted dorsally, those of the oral series being slightly longer. All are sharply pointed. The body surface has a covering of small, slightly curved, spinules distributed ventrally as far back as the posterior border of the ventral sucker, but on the dorsal surface the rows terminate a little in front of this level. The prepharynx, small pharynx, very long oesophagus, and intestinal crura are typical of the echinostome group.

The details of the excretory system are very difficult to determine. The terminal muscular sac is sometimes differentiated into a posterior rounded or squarish part and an anterior smaller, narrower portion formed by the bases of the two long excretory ducts. The latter contain a few minute refracting granules in their postacetabular portion, the number increasing greatly in the preacetabular part of the tube where the concretions are larger and closely packed, three or four occupying the lumen in transection. The duct (concretional descending tube of Johnson, 1920) narrows near the level of the prepharynx, forms a loop just behind the collar region, and then travels back (as the ascending tube of Johnson) close to the descending duct, the two parting company at the level of the anterior acetabular region. This ascending canal divides at about the level

of the middle of the bladder, the anterior collecting tube passing forwards in company with the ascending canal, to terminate beside the oral sucker. The ascending canal has a number of ciliated areas, at least seventeen flames (obvious only at the death of the cercaria) being counted from its posterior extremity to the level of the mid-oesophagus. The anterior collecting tube has six flame cells connected singly with it and distributed in the region between the oral sucker and the intestinal bifurcation. At the level of the anterior part of the acetabulum there are three flame cells, probably forming one group; then follow six others (probably two groups each of three flames) between the first group and the point of origin of the ascending canal. The posterior collecting tube is short and has three groups of flames, three in each, associated with it; the most anterior of these groups arising almost at the point of origin of the posterior collecting tube. Thus there are apparently 24 flame cells on each side, the general arrangement resembling closely that described for *Echinostoma revolutum* (Johnson, 1920; also comments by Beaver, 1937, 87, and by Sewell, 1922, 130 and 117 footnote). A caudal excretory canal passes back from the bladder and soon bifurcates, each branch travelling almost directly outwards to open on the corresponding side of the tail.

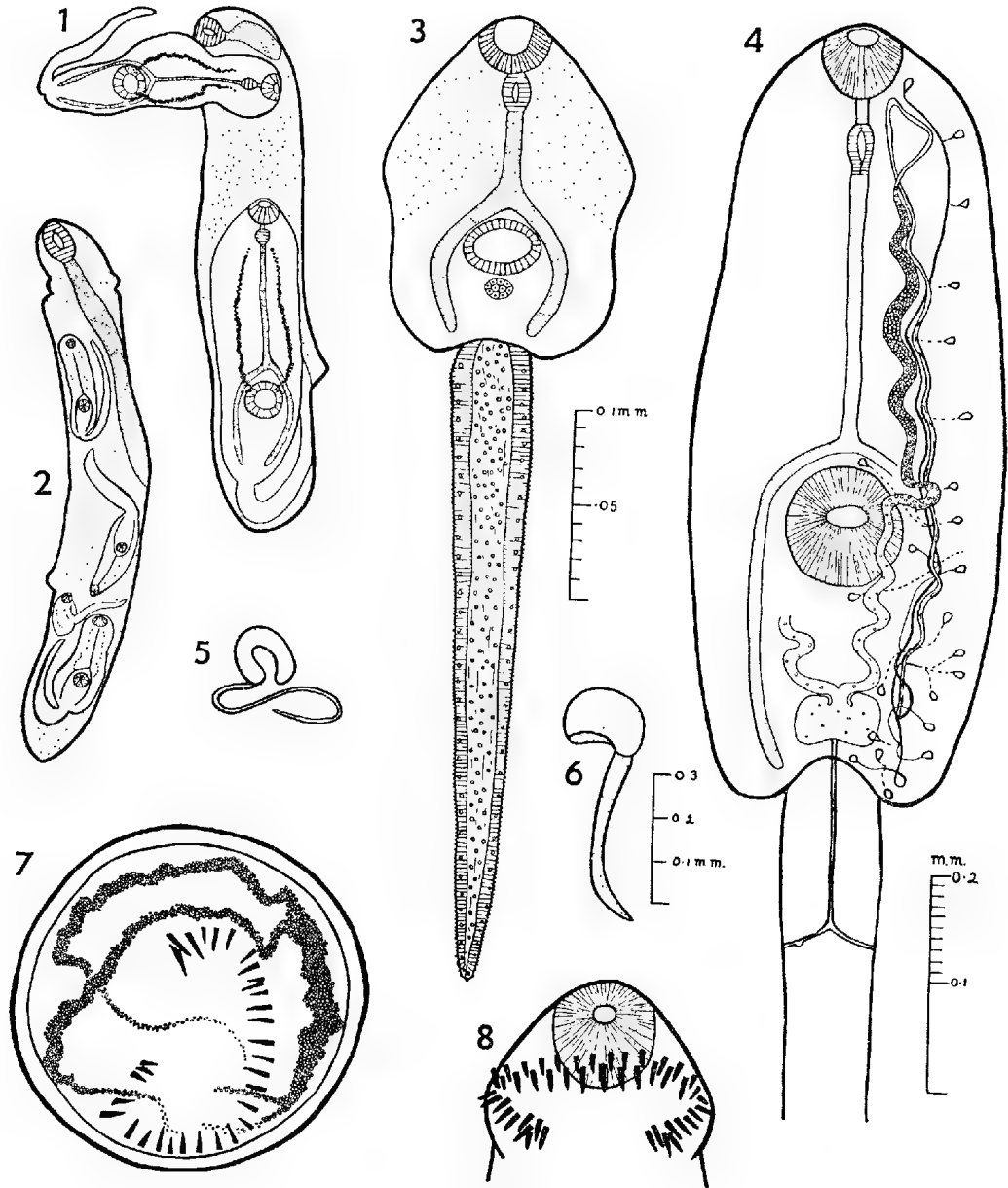
In some cercariae a small aggregation of cells, the genital anlagen, may be seen just behind the acetabulum, and a smaller group between the latter and the intestinal bifurcation represents the rudiment of the genital pore and associated ducts. Comparatively large cystogenous gland cells are abundant, forming a more or less continuous layer in the body, about nine of these cells occupying the body width in the postacetabular region.

The redia stage was found chiefly in the liver of the snail. The apex of the organ generally contained abundant encysted metacercariae with few rediae, this region being followed by a part of the liver packed with rediae and containing fewer cysts. Occasional rediae were found distributed through the rest of the body as far forward as the anterior portion of the pulmonary chamber. This stage apparently represents the daughter redia generation. Sporocysts and mother rediae were not seen. The rediae vary from colourless to bright orange and measure up to 1.2 mm. long by 0.16 mm. wide. Each usually contains two or three cercariae, rarely more than six. There are a prominent pharynx, short dark intestine, prominent foot processes and a more or less inconspicuous collar just behind which is the birth pore. Flame cells and excretory tubes were not recognised.

It was ascertained that the cercariae did not invade fish (such as carp) or a planarian, *Convoluta*, but would enter other molluscs such as the pond snails, *Ameria pyramidata* and *A. pectorosa*, *Planorbis isingi* and *Lymnaea lessonae*, as well as the bivalve *Corbiculina angasi*. Our observations indicate that *Planorbis* is the preferred second intermediate host, the invasion of *Ameria* being slight compared with that of *Planorbis* when both are placed in the same small aquarium with the cercariae.

The cysts of the metacercaria were found chiefly in the liver and quite often within rediae. They are very uniform in size, 150-159 μ in diameter, with a firm

thin transparent cyst wall through which the collar and body spines, suckers, and main concretionary excretory canals are visible. The metacercariae, expressed from their cysts, show very little advance in development from the cercaria, though the



Figs 1-8

Figs. 1-8 *Cercaria clelandae*: 1, redia with escaping cercaria; 2, redia with intestine longer than usual; 3, cercaria (formalinised) showing region of spination dorsally; 4, extended cercaria, showing excretory system, fifth group (counting from posterior end) shown incomplete—the suggested connections of some flame cells with the collecting tubules are indicated by dotted lines; 5, sketch of cercaria in movement; 6, resting position, same as in formalinised specimen; 7, metacercaria, suckers not indicated and full number of collar spines not shown; 8, head end of metacercaria. Figs 1, 2 and 6 are drawn to same scale; figs. 3, 7 and 8.

collar spines and body spination are more obvious. Over 200 cysts were fed to two ducks and a rat in the hope of obtaining the adult stage, but without success.

The absence of a fin fold on the tail, the presence of body spines on both surfaces, the arrangement of the collar spines in a double row, and the point of branching of the main excretory canal, place this echinostome cercaria in the *echinata* group of Sewell (1922), to which *Echinostoma revolutum* belongs. The disposition of the collar spines in a double row, uninterrupted dorsally, and the differentiation in size of the spines of the oral and aboral rows, together with the distribution of the body spines, suggest that the adult may be an *Echinostoma* or an *Echinoparyphium*. In the presence of 45 collar spines (including the four in each corner) it resembles some species of both these genera. Amongst these are *Echinoparyphium recurvatum* and *E. flexum* (Linton) whose collar armature is very like that of our form. Our cercaria and redia closely resemble those of the former species as described by Wesenberg-Lund (1934), except that the point of bifurcation of the main excretory canals in the cercariae is differently situated. In *E. flexum*, McCoy (1928, 208), whose account of the cercaria is very brief, described the bifurcation as occurring at the level of the posterior end of the ventral sucker. All the species of *Echinoparyphium* so far recorded from Australia by S. J. Johnston (1916) can be excluded because of the number and arrangement of the collar spines. Some species of *Echinostoma* having 45 spines have been described from the Commonwealth. *E. bancrofti* T. H. Johnston from *Gallinula* possesses spines of a different form and the presence or absence of body spinules is not recorded. *E. australasianum* Nicoll from *Antigone* differs in regard to the relative sizes of the spines of the two rows. A European species, *E. baculus* Dies., as figured by Dietz, has a much more marked difference in size between the corner spines and those of the rest of the series, and, besides, body spinules are stated to be absent. We expect the adult stage to occur in some bird which utilises pond snails as a food supply.

We have named the organism *Cercaria clelandae* n. sp. in recognition of the work of our former colleague, Miss E. R. Cleland (now Mrs. Simpson).

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SUNDRY NEMATODES FROM EASTERN AUSTRALIAN MARSUPIALS

By T. HARVEY. JOHNSTON and PATRICIA M. MAWSON, University of Adelaide

Summary

We published recently some papers dealing with Strongylate nematodes from marsupials in Queensland and New South Wales. The present paper refers mainly to representatives of other nematode groups which are not commonly met with in that mammalian order. For some of the material we are indebted to Mr. L. Gallard, of Narara, near Gosford, N.S.W. (1909-1910), most of the remainder having been collected by the senior author during the same period. The present investigation was carried out in accordance with the terms of a Commonwealth Research grant to the University of Adelaide. Types of the new species have been deposited in the South Australian Museum.

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LIST OF HOSTS AND PARASITES REFERRED TO

- Perameles nasuta* Geoffr.: *Subulura peramelis* Baylis, **Physaloptera peramelis** n. sp., *Dipetalonema* sp., *Trichuris peramelis* Baylis.
Dasyurus viverrinus Shaw: *Echinonema cinctum* Linstow.
Trichosurus vulpecula Shaw: *Protospirura marsupialis* Baylis.
Petrogale penicillata Gray: *Dipetalonema* sp.
Macropus ruficollis Desm.: *Dipetalonema* sp.
Macropus ualabatus Less. and Garn.: *Dipetalonema spelaea* Leidy.
Macropus agilis Gould: *Macropostrongylus macropostrongylus* Y. and M., *M. yorkci* Baylis.

Certain other strongyles, described recently by Davey and Wood (1938), are referred to, and a new name is proposed for our *Cloacina minor* (J. and M., 1938).

SUBULURA PERAMELIS Baylis

(Fig. 1)

From the intestine of a bandicoot, *Perameles nasuta*, Gosford district, N.S.W. (coll. L. Gallard). Only females were collected, 20-21 mm. long. Anterior end with two lateral and four submedian lips, as well as six shorter intermediate processes; lateral lips each with papilla; intermediate process on each side of lateral lip also with papilla; lips much longer than those indicated in Baylis' figure. Mouth small; buccal cavity about 20 μ diameter anteriorly, widening at base to about 100 μ , posterior limit difficult to determine, walls thick and chitinated; three large rounded teeth at base of capsule, but accessory teeth not observed. Oesophagus 1.9 mm. long, widening gradually until near base where it becomes deeply constricted and then expanded into a large almost spherical bulb, about 0.2 mm. diameter. Nerve cord not observed. Excretory pore at about mid-length of oesophagus, and 0.65 mm. from anterior end of worm.

Body tapering gradually posteriorly, narrowing suddenly near the tip of the tail; latter conical with tiny papilla at tip; tail 0.5 mm. long; vulva 9 mm. from anterior end, just in front of mid-length of body; uteri divergent; eggs asymmetrical, $30 \times 40 \mu$, thick-shelled.

Our specimens show some differences from Baylis' account (1930) of the species, collected from *Perameles obesula*, in North Queensland. They are much longer, and have a larger buccal capsule, longer lips and much smaller eggs.

***Physaloptera peramelis* n. sp.**

(Figs. 2-4)

From stomach of *Perameles nasuta* from Gosford district (L. Gallard), and from three others from Sydney district.

Males 20-30 mm., females 30-40 mm. long. Cuticle very finely striated longitudinally; reflexed around lips but not completely enclosing them. Two lateral lips each with an outer median tooth, internal to latter is a tripartite tooth; each lip bearing a subventral and a subdorsal papilla, and possibly also a larger lateral papilla. Oesophagus 4.3 mm. long in female, anterior muscular portion 0.6 mm. long. Nerve ring at 0.45 mm., and excretory pore at 0.75 mm. from head end. Cervical papillae just in front of level of excretory pore.

Male—Posterior end thick; caudal papillae difficult to distinguish; six pedunculate papillae seen on one side, four similar papillae on opposite side; five and three respectively of these were preanal; also three (? two pairs) just in front of anus and four pairs behind anus. Bursa 1 mm. long; our figure is drawn from a dorso-ventrally flattened specimen in which the anterior edge is bent over so that the bursa appears relatively wider than normal. Spicules unequal; one longer, thinner, 0.6 mm. long, 0.04 mm. wide at its base, tapering to a fine point; the other 0.3 mm. (possibly more) long, 0.06 mm. wide at base, tapering towards free end, suddenly constricted near short rounded tip. Surface of bursa with tubercles.

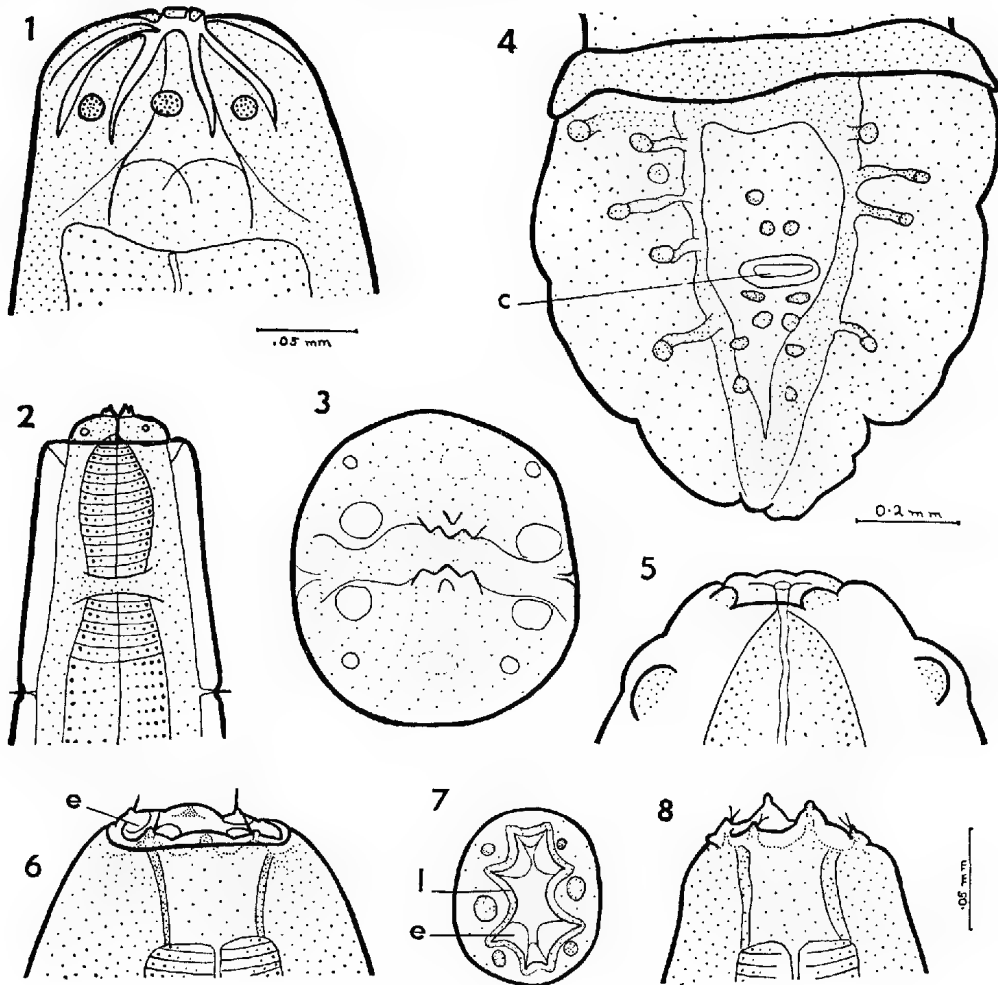
Female—Probably only two ovaries. Tail bluntly conical; anus 0.45 mm. from its tip. Vulva at about one-fifth body length from head end; 2.85 mm. behind termination of oesophagus. Eggs 45 by 34μ , with larvae and thick shells.

To this species belongs the specimen described (not named) by Ortlepp (1922, 1080-1, fig. 44) from the same host species from London Zoological Gardens, the locality being indicated merely as Australia. Ortlepp found five pairs of postanal papillae in the median series.

***Echinonema cinctum* Linstow, 1898**

A female specimen, 13.1 mm. long, was taken from the intestine of a "native cat," *Dasyurus viverrinus*, in Sydney. The general form of the body agrees with Linstow's account, but the head bears three rows of spines instead of two as stated by him; besides, all spines are shorter than his measurements, the head appears shorter, and the neck is indicated as more markedly constricted. Yorke and Maplestone (1926), in their generic diagnosis for *Echinonema*, stated that

there were three rows of spines on the head, and their figure shows such an arrangement. Since the figure is an original one, we assume that it was based on material collected from a bandicoot in the vicinity of Townsville, North Queensland, Maplestone having been for some time associated with the Institute of Tropical Medicine. Linstow's material came from *Isodon obesulus* from the Upper Burnett River, that species being represented by a very closely related form, *I. macrura*, in northern coastal Queensland.



Figs. 1-8

Fig. 1, *Subulura peramelis*, head. Figs. 2-4, *Physaloptera peramelis*: 2, anterior end; 3, head, anterior view; 4, bursa. Fig. 5, *Difftalonema* sp. from *Perameles nasuta*, head. Figs. 6-7, *Macropostrongylus yorki*: 6, head, lateral view; 7, head, anterior view. Fig. 8, *Macropostrongylus macropostrongylus*, head. Figs 1 and 3 are drawn to same scale; 2 and 4; 5 to 8. c, cloaca; e, element of leaf crown; l, lateral lip.

In spite of the discrepancy between Linstow's account and the observations of Yorke and Maplestone and of ourselves, we regard our specimen as belonging to *E. cinctum*. The spines of the third row are much shorter and thinner and

less obvious than those of the first and second rows, and were probably overlooked by Linstow, whose specimens were perhaps also in a different state of contraction, causing the difference in the form of the head and neck and in the disposition of the spines.

There are 14-16 spines in each row in our specimen, their length being 0.13, 0.14 and 0.08 mm., respectively. Then follows an unarmed, slightly narrower, region, measuring 0.06 mm. behind the tip of the spines of the third row; this neck region being succeeded by nineteen rows of shorter spines occupying an area extending back 1.5 mm. from the head end. The spines of the first two and the last three rows are 0.01 mm. long; those of intermediate rows 0.04-0.05 mm. long. Behind this spiny zone, the remainder of the body is covered with minute spinules. Oesophagus 1.1 mm. long, 1:12 of body length; tail 0.5 mm. long.

PROTOSPIRURA MARSUPIALIS Baylis

This large nematode is now recorded from *Trichosurus vulpecula* from the vicinity of Sydney. It is already known from Queensland.

DIPETALONEMA SPELAEA (Leidy)

A male specimen from the body cavity of *Macropus ualabatus* from the Blue Mountains, New South Wales. In recording the presence of *Filaria* sp. from the host, the senior author (1909) stated that the species appeared to be *F. spelaea*. Our re-examination of the original specimen has shown it to belong to Leidy's species.

DIPETALONEMA sp.

An immature female from the vicinity of the liver of *Macropus ruficollis*, from the Gosford district, New South Wales. Length 62 mm.; maximum breadth 0.7 mm.; width across head 0.13 mm.; width at anus 0.13 mm.; tail 0.1 mm. long, conical, with a pair of minute rounded subterminal papillae on ventral side. Cuticle striated transversely.

DIPETALONEMA sp.

A female, considerably shrunken and macerated, 95 mm. long, was found in the body cavity of the rock wallaby, *Petrogale penicillata*, from the Gosford district (coll. L. Gallard).

DIPETALONEMA sp.

(Fig. 5)

A female from the lung of *Perameles nasuta*, from Sydney. The specimen is a fragment 50 mm. long, with the cuticle striated longitudinally. Head with four, perhaps six, low circum-oral papillae and at least four larger papillae further back. Further details cannot be detected. The head bears a strong resemblance to that figured by Linstow (1898, 470) for an unidentified nematode from *Dasypus* (error for *Dasyurus*) *hallucatus* Gould from the Upper Burnett, Queensland. They probably belong to the same species. Two rows of papillae occur also in

D. robertsi Johnston and Mawson, 1938, but the head is larger and the circumoral papillae closer to the mouth than in the latter species.

TRICHURIS PERAMELIS Baylis

A number of females, some of them fragmentary, were found in the intestine of *Perameles nasuta*, from the vicinity of Sydney. Length 6.5-10.1 mm. In the largest specimen the oesophageal region was 5.7 and the rest of the body 5.4 mm. Maximum breadth of anterior region 0.05 mm.; of posterior region 0.08 mm.; width at junction of the two parts 0.06 mm. Cuticular striations not recognised. Eggs 44-46 μ long (including polar plugs); 20-23 μ wide.

Our specimens show considerable differences from the females of Baylis' species which was obtained from *Isodon obesulus* from North Queensland. These may be tabulated:

	<i>T. peramelis</i> Baylis	N.S.W. Specimens
Length of female - - -	11 to 19.5 mm.	6.5—10.1 mm.
Oesophagus: body length -	2:3; 3:4	1:2
Length of oesophageal region	8.3—15.4 mm.	5.7
Length of posterior region -	2.7—5.5 mm.	5.4
Maximum breadth - - -	0.19—0.33 mm.	0.08
Breadth at junction of the two regions - - - -	0.1—0.17 mm.	0.06
Eggs - - - - -	0.053 by 0.028—0.03 mm.	0.02—0.023 mm.

It is with considerable doubt that we place our specimens under *T. peramelis*, but in view of the few females examined, and the absence of males, we deem it unwise to erect a new species.

CLOACINA CORNUTA (Davey and Wood, 1938) J. and M.

This species was described from *Macropus agilis*, North Queensland, as *Macropostrongylus cornutus*, but its characters appear to us to agree with those of *Cloacina*, a revised diagnosis of which was published recently by us (1938) and a comparison with *Macropostrongylus* was made. *C. cornuta* resembles *C. robertsi* J. and M. (1939) in many features, but possesses longer submedian papillae; a relatively deeper, thinner and more anteriorly placed buccal ring; shorter spicules; and a differently shaped dorsal ray. It also resembles *C. similis* J. and M. (1939) in regard to the head papillae and most measurements, but the former has a shallower buccal ring, slightly shorter spicules, and a narrower female tail.

CLOACINA MINOR (Davey and Wood, 1938) J. and M.

This species from *Macropus robustus*, North Queensland, was placed under *Macropostrongylus*, but we refer it to *Cloacina*. The head is rather like that of *C. macropodis* J. and M. (1938), but the papillae are larger and the buccal ring thinner, while the dorsal ray has shorter terminal branches, and the length of the spicules and relative positions of the anus and vulva are different.

***Cloacina longelabiata* nom. nov.**

Our assignment of *Macropostrongylus minor* Davey and Wood (1938) to *Cloacina* necessitates the renaming of our *C. minor*, the accounts of both species having appeared in 1938, but the former has priority. We suggest *C. longelabiata* for our form on account of its long wide lips.

PHARYNGOSTRONGYLUS ORNATUS Davey and Wood, 1938

This worm from *Macropus robustus*, North Queensland, resembles closely *P. gamma* J. and M. (1939) but differs in the length of the dorsal ray, ratio of spicule to body length, position of cervical papillae and excretory pore, form of the oral papillae, and the absence of bifid bristles on the papillae.

REMARKS ON MACROPOSTRONGYLUS

(Figs. 6-8)

Specimens of *M. macropostrongylus* Yorke and Maplestone and *M. yorkei* Baylis, recorded recently by us (1939) from *Macropus agilis* from North Queensland, were examined. In both species there are setae on the submedian papillae—a single long bristle on each in *M. yorkei*, and a pair on each in *M. macropostrongylus*.

Baylis in his account of *M. yorkei* was doubtful regarding the presence of a leaf-crown, but the structure occurs in our specimens where it consists of six elements in submedian, dorsal and ventral positions, the dorsal and ventral elements being much smaller than the others. The wide lateral lips appear to be without elements. The head of *M. yorkei* is indicated in figs. 6-7, and that of *M. macropostrongylus* in fig. 8.

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A SOUTH AUSTRALIAN SPHAGNUM BOG

By R. L. CROCKER and C. M. EARDLEY
(Department of Botany and Waite Agricultural Research Institute,
University of Adelaide, South Australia)

Summary

Special interest centres round the discovery early this year of two small *Sphagnum* bogs near Lake Leake, a few miles east of Millicent in the South-East of South Australia. Such bogs, on account of their high acidity and oligotrophic character, provide a very specialized habitat for plant life, and their study affords valuable information about problems of plant distribution (Baas Becking and Nicolai, 1934; Wood and Baas Becking, 1937).

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[Read 10 August 1939]

PLATE VIII

Special interest centres round the discovery early this year of two small *Sphagnum* bogs near Lake Leake, a few miles east of Millicent in the South-East of South Australia. Such bogs, on account of their high acidity and oligotrophic character, provide a very specialized habitat for plant life, and their study affords valuable information about problems of plant distribution (Baas Becking and Nicolai, 1934; Wood and Baas Becking, 1937).

In poorly aerated soils saturated with water where conditions for bacterial decomposition are unfavourable, peat may be formed from a variety of vascular plants, mosses and lichens. In peats the plant structures usually remain intact, and the level of the bog is gradually raised by the addition of further plant remains.

The reaction of peat bogs varies. The "Fen peats" of East Anglia occur in areas where the ground waters contain much calcium carbonate, and where the soil level is not appreciably higher than the water table. Such peats are often alkaline. The peat formers are members of the Cyperaceae and Juncaceae, and as the fen peat is built up it may become high enough to develop a more acid or "Hochmoor" peat (Braun-Blanquet, 1932; Ashby, Richter and Bärner, 1938).

Sphagnum peats are invariably acid in reaction (pH 3.7-4.5, Baas Becking and Nicolai, 1934; Wood and Baas Becking, 1937). The bog near Millicent occurs in one of the wettest parts of the South-East (the rainfall at Lake Leake is 33 inches per annum) and has a typical acid reaction—pH 4.3. Another acid peat (pH 4.0-4.5) occurs at Square Waterhole, Mount Compass, South Australia; there the peat formers are members of the families Cyperaceae and Restionaceae (Adamson and Osborn, 1924). Observations by Stelmach (quoted by Baas Becking and Nicolai, 1934), show that some species of *Sphagnum* can decrease the pH of weakly alkaline culture solutions, whilst one at least can cause an increase in the pH of the culture medium. The mechanism of this change in pH by *Sphagnum* is not clear, but Baumann and Gully (quoted by Baas Becking and Nicolai, 1934), suggest that the cell wall is colloidal and can exchange ions with the soil solution, cations being absorbed whilst hydrogen ions are freed from the cell wall.

SPHAGNUM in South Australia

Sphagnum spp. have been found in quantity in New South Wales, Victoria and Tasmania (Watts and Whitelegge, 1902, and Watts, 1912), and one small area in Western Australia has been discovered near Pemberton (Nicholls, 1932). Search through the literature for previous records of *Sphagnum* in South Aus-

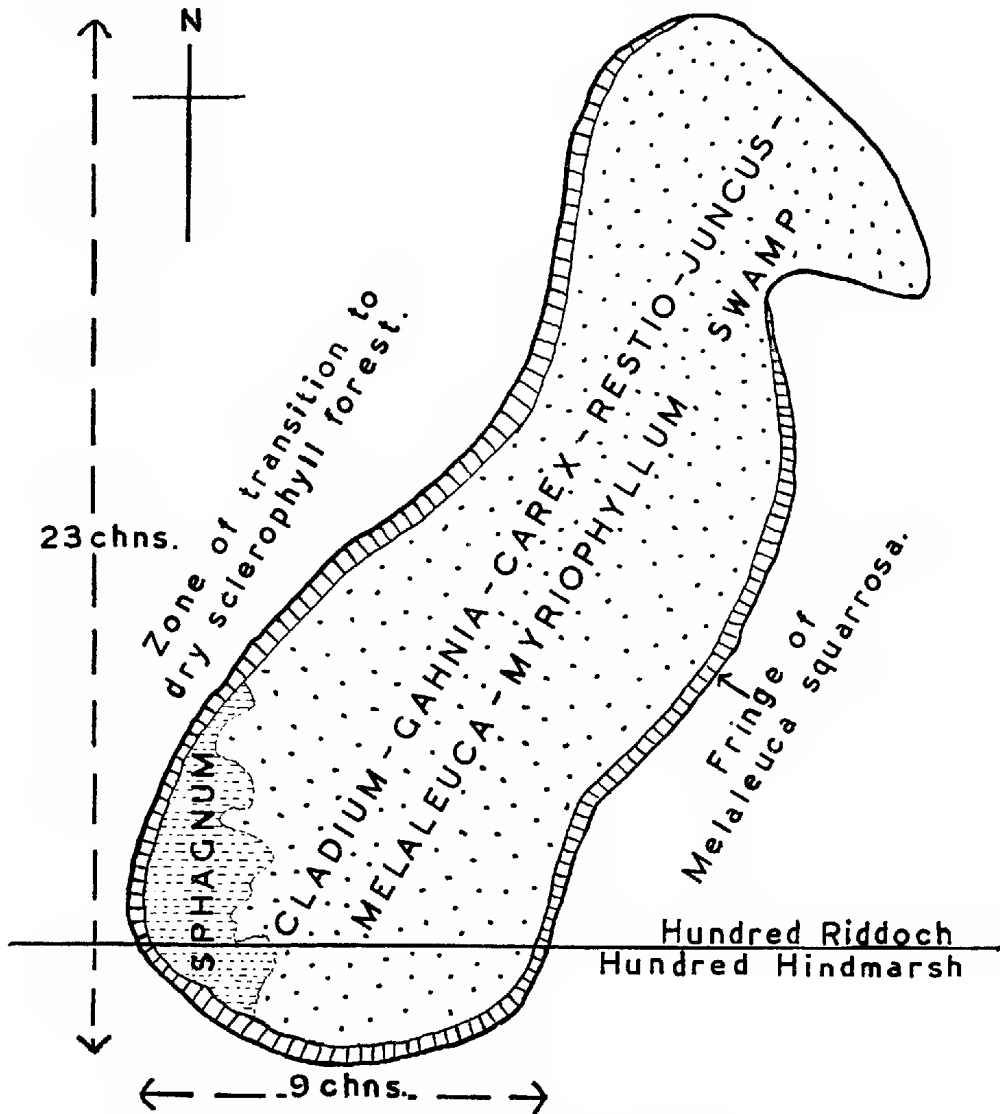


Fig. 1

Plan to show Vegetation of *Sphagnum* Peat Bog

tralia has not proved very fruitful. Mueller (1881) does not record *Sphagnum* for South Australia in his lists of Australian mosses in the last volume of his "Fragmenta," but amongst correspondence between Mueller and Tate recently discovered in the Department of Botany, one letter by Mueller refers to a

"*Sphagnum* bog near Mount McIntyre" which Tate had visited in November, 1882. Tate (1883), in his account of this journey, records two species of vascular plants collected in a "*Sphagnum* bog near Mount McIntyre" and three from "Lake Leake." *Sphagnum* itself is not mentioned in his lists. These localities coincide almost exactly with the present occurrences.

The only authentic records for *Sphagnum* in South Australia appear to be two quoted by Watts (1912) and Watts and Whitelegge (1902). These two species were collected about 1900 or earlier by a Miss Campbell (later Mrs. Flora M. Martin), who apparently lived in Victoria and sent collections of mosses to F. M. Bailey in Queensland and who, in turn, forwarded them to Brotherus in Helsingfors. The only locality quoted is "South Australia." C. Warnstorf (1911) in his monograph on the *Sphagna* of the world, erected a new species (*Sphagnum dubiosum* C. Warnstorf) on one of these specimens. The other is *Sphagnum subbicolor*, Hampe which is found in all the eastern States. It is not known at present whether our specimens belong to one of these species, but they have been sent to an expert for determination.

Locality and Vegetation of the Millicent SPHAGNUM Peat Bogs

The bogs occur on the boundaries of Hundreds Riddoch and Hindmarsh in a poorly drained, swampy region, approximately 150 feet above sea level. On the higher podsolised soils the vegetation consists of *Eucalyptus Baxteri* (Benth.), Maid. et Blakely, dry sclerophyll forest intermixed with patches of heath. The more important bog is mapped in fig. 1.

The area is not large (approximately 200 yards by 600 yards), and the *Sphagnum*, which is only a few inches high, is confined to a small patch in one corner. *Myriophyllum propinquum* A. Cunn., replaces *Sphagnum* in the rest of the bog and merges with it at their conjunction. *Myriophyllum* is probably also a peat former.

Species of Cyperaceae, Restionaceae and *Melaleuca* occur in clumps throughout the bog and a fringe of *Melaleuca squarrosa* Donn. practically surrounds the bog, and separates it from the dry sclerophyll forest.

Eucalyptus Huberiana Naudin occurs in the transitional zone between *Melaleuca squarrosa* Donn. and the *Eucalyptus Baxteri* dry sclerophyll forest.

The plants associated with *Euc. Baxteri* (Benth.) Maid et Blakely, in the dry sclerophyll forest, are: *Pteridium aquilinum* (L.) Kuhn (Bracken), *Acacia oxycedrus* Sieb., *A. melanoxylon* R. Br., *Leptospermum scoparium* Forst et f., *Eucalyptus Huberiana* Naudin (kindly determined by Mr. W. F. Blakely), and *Epacris impressa*, Labill.

The plants found in the bog itself are: *Sphagnum* sp., *Cladium articulatum* R. Br., *Gahnia psittacorum* Labill., *Carex* (*appressa* ?), *Restio tetraphyllus* Labill., *Leptocarpus tenax* R. Br., *Xyris operculata* Labill., *Juncus pallidus* R. Br., *Leptospermum scoparium* Forst., et f., *Melaleuca squarrosa* Donn., and *Myriophyllum propinquum* A. Cunn.

Both lists of plants are probably incomplete, since the areas have only been visited at the end of an exceptionally dry and hot season. It would be desirable to investigate the microscopic algae and bacterial flora also.

Particular interest is attached to the finding of *Restio tetraphyllus* Labill. in the South-East. This plant, known as Tassel Cord-rush in Victoria (Ewart, 1930), forms large tussocks four to five feet high (Pl. viii). The plant is dioecious and, on this occasion, only female flowers have been found. Tate (1890) in his "Flora of Extratropical South Australia" records both *Restio tetraphyllus* Labill. and *Restio complanatus* R. Br. for the Mount Gambier district. J. M. Black (1922), in his recent "Flora of South Australia," did not quote these records of Tate, since they could not be authenticated by South Australian specimens in either the Adelaide or Melbourne Herbaria.

Distribution of SPHAGNUM

The discontinuous distribution of *Sphagnum* in Australia has been noted above. The nearest recorded occurrence of *Sphagnum* to the South Australian South-Eastern bogs and to those of Western Victoria is at Mount William, 40 miles north of Melbourne, over 200 miles away. Baas Becking, in a series of publications (1934 and others), and Wood and Baas Becking (1937) have emphasised the cosmopolitan distribution of the spores of most cryptogamic plants and also the selectivity of the environment. The distribution of *Sphagnum* in Australia supports the thesis that similar or identical plant communities occur where the environmental conditions are similar and extreme.

SUMMARY

The unusual occurrence of two small typically acid *Sphagnum* peat bogs near Millicent, in South Australia, is recorded in a rainfall area of 33 inches.

The vegetation of one of them and its surroundings are described. Among the plants on the bog is *Restio tetraphyllus* Labill., a large tussock rush found in Victoria, but apparently of very restricted distribution in South Australia, as it has not been recorded in this State since 1890.

It is concluded that the presence of these *Sphagnum* bogs is due entirely to the selectivity of the environment since the spores of cryptogamic plants are practically universal.

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The Government Botanist in Victoria, Mr. F. J. Rac, kindly checked specimens of *Restio tetraphyllus* Labill. in the National Herbarium in Melbourne; and it is also desired to thank Miss Joyce Vickery of the National Herbarium, Sydney, and Miss Alison Baird of the Botanical Department in the University of Western Australia, for help in tracing *Sphagnum* records and literature.

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Sphagnum—Myriophyllum peat bog near Lake Leake.
The taller plants shown are *Cladium articulatum* (left foreground) and
Restio tetraphyllus (Tassel Cord-rush) on the right and in the distance.

ECOLOGICAL CONCEPTS AND NOMENCLATURE

By J. G. WOOD Department of Botany, University of Adelaide

Summary

Ecology in Australia has reached a stage at which the major plant communities have been described. The accumulation of this knowledge has resulted in a state of affairs not unknown in other parts of the world; many workers in Australia (Patton, 1933; Blake, 1938; Pidgeon, 1937; Wood, 1937) have stressed the inadequacy of existing systems of classification and their failure to account for the status and relations of plant communities. Further progress in Australian ecology demands some degree of clarification and unification of these systems, and in this paper it is proposed to review ecological concepts from the standpoint of certain fundamental considerations and from actual experience with Australian communities.

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[Read 10 August 1939]

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FUNDAMENTAL CONSIDERATIONS

Underlying all ecological work is the fundamental fact that any particular plant species requires for its existence a certain environment. Similarly any natural assemblage of species is characterised by a definite environment, although individual members in the community may possess a wider potential environment. The assemblage of species indeed owes its existence in large measure to the fact that its components have been selected by the environment.

Added to this is the further fact of experience that the initial assemblage of species in any environment is capable of altering the chemical environment, and so producing ultimately a change in the composition of the species-aggregate.

These two fundamental facts—selectivity of the environment and change—are illustrated most clearly in cryptogamic communities in extreme environments. In aqueous milieu the water factor and its sometimes profound influences on metabolism are excluded, and consequently this environment may be characterised with greater precision than subaerial environments. The more extreme the aqueous milieu, as in peat water, hot springs, evaporating brine, the more restricted become the species capable of living in such environments; and further, owing to the universal distribution of spores of most cryptogams and bacteria, the community in extreme milieus tends to a constant species-composition (Baas Becking, 1934). Furthermore, in these extreme environments unstable and stable communities can be distinguished. In concentrated salt-brines, for example, the pioneer species is a green alga, *Dunaliella*, which on death alters the chemical environment by providing cellulose, so that cellulose-destroying bacteria appear; these, in turn, are followed by anaerobic sulphate-reducing bacteria which reduce sulphates to sulphides, the latter providing a substrate for autotrophic purple bacteria. With the changes in composition of the medium brought about by the

species themselves we see a succession of unstable communities, and finally a relatively stable one. The stable community has a species composition different from the unstable ones but derived from them by competition, and it is also

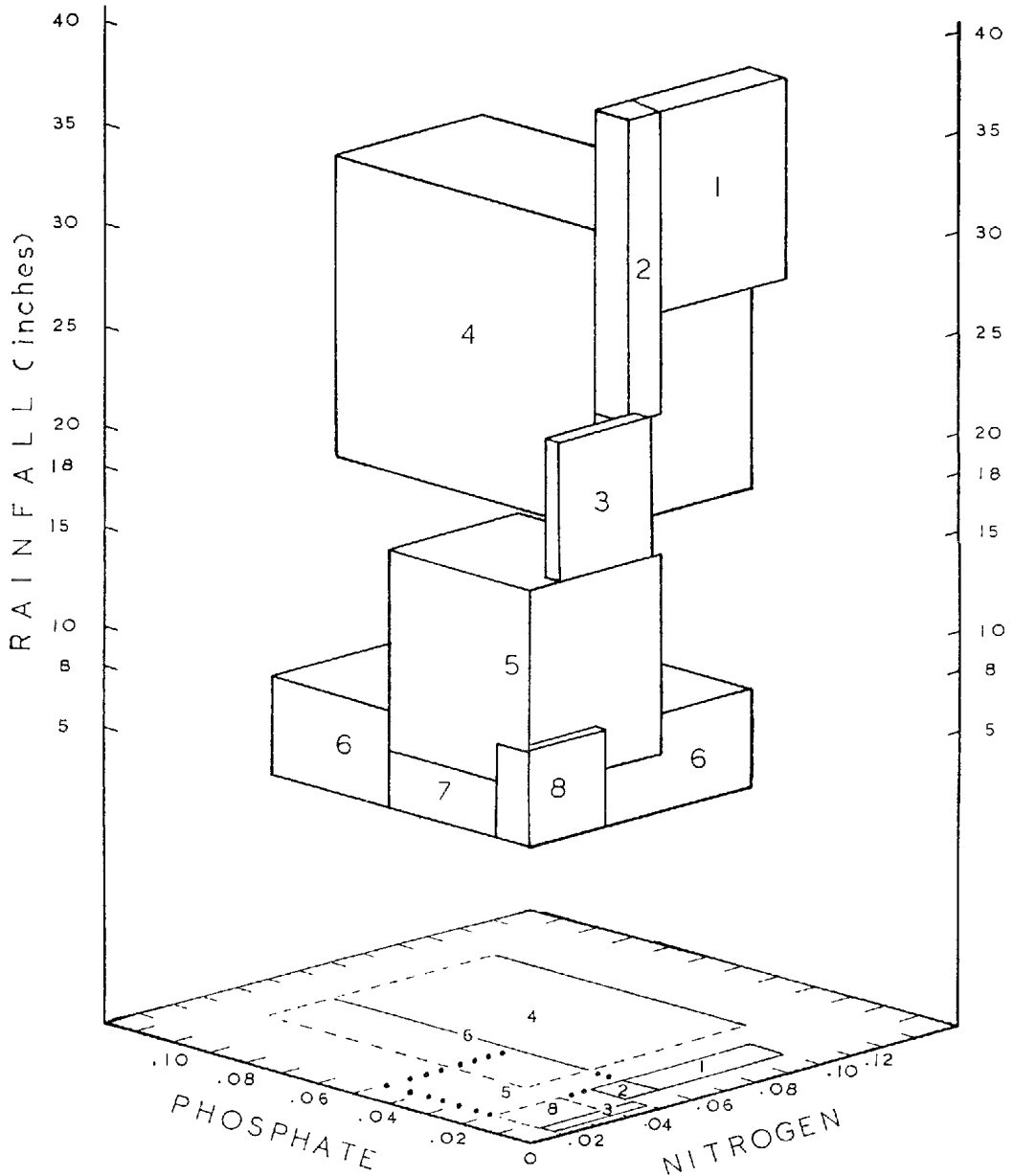


Fig. 1

Three dimensional diagram illustrating relations of plant associations to phosphate (P_2O_5), nitrogen and rainfall.

1, *Euc. obliqua* forest; 2, *Euc. Baxteri-Euc. cosmophylla* scrub; 3, *Euc. diversifolia* scrub; 4, *Euc. leucoxyton* savannah woodland; 5, mallee; 6, *Atriplex vesicarium* scrubland; 7, mulga scrub; 8, *Triodia* desert.

characterised by a definite chemical environment. Brines of different salt concentrations contain communities differing in their final species composition; these are stable and only change when the medium changes in composition due to external causes.

Even in subaerial communities of phanerogamic plants where universal distribution of seeds is no longer possible and where the water factor becomes prominent, convergence of species in similar environments, and especially in extreme environments, is marked (Wood and Baas Becking, 1937).

Baas Becking and his collaborators (1934) have defined the chemical milieu of a few organisms living in aqueous environments. If we knew the environmental limits for every species in the flora of a country, we could in large measure define the composition of a plant community which would occur in any particular habitat; but only partially so since the factor of competition between species has been left out of consideration. Figures 1 and 2, derived from the extensive data of Prescott (1931), Prescott and Piper (1932), Prescott and Skewes (1938), Piper (1938), Taylor (1933), Taylor and O'Donnell (1932) and Wood (1937), show how closely the vegetation communities in South Australia are determined by climate and by chemical factors of the environment.

Any system of classification of plant communities must include the ideas of floristic composition determined by environment and of change.

VEGETATIONAL STATICS

The Third Botanical Congress defined the unit of vegetation as a "community of definite floristic composition." The idea of the community is an abstraction but rests upon a basis of reality. The reality is the fact of experience that species of plants tend to occur together in definite combinations which we call a community. Pieces of vegetation (*stands*) show a few species constantly present and prominent in the community as a whole. These species are not necessarily the most numerous, but they frequently occupy more cover than other species and give a distinct look or facies to the community. These species we call dominants; they are capable of existing in a greater range of environmental conditions and are often more aggressive than other species more or less frequently associated with them.

For the delimitation of a community it is necessary to examine a large number of stands with similar combinations of species, preferably spatially separated from one another. The greater the number of stands examined the more truthful becomes the picture of the community. The community may be named from its dominants.

Experience shows that these units can be divided into two classes: first, communities which are relatively stable in a well-defined environment, and second, communities which are unstable and in which individual species gradually alter the edaphic environment and eventually give rise to more stable communities. The stable communities are called *associations*. The unstable units which show a

succession to an association following Braun-Blanquet (1932) and avoiding the controversial word "associes" we may call *stages*.

The fundamental picture is similar to that described previously for simpler aquatic milieus, namely, the association is the resultant from the interaction of two sets of factors: those of the environment which is selective and that of competition. The association as defined above is readily recognised in the field and forms the static social unit in any system of classification. Associations may be grouped into larger units on a floristic basis, but such groupings are obviously undesirable since they neglect habitat factors and competition.

VEGETATIONAL DYNAMICS

European ecologists limit the term succession to the series of stages which culminate in the association. Clements (1916), and following him Tansley, considered that the associations as defined above were capable of further changes which were grouped under the general term succession. He also introduced the idea of the mono-climatic climax, *i.e.*, a terminal community determined by climate alone and independent of soil type. Tansley (1935), on the other hand, has recognised that different soil types may occur within the same climatic zone and give rise to different "edaphic climaxes," the terminology of Clements is retained, however, in that edaphic climaxes are regarded as sub-climaxes of the climatic climax.

The soil types of the earth are in general conditioned by climate, but not invariably so. Sometimes the nature of the geological substratum influences soil development profoundly, both in texture and in chemical make-up; examples in South Australia are continuous areas in the same climatic zone of podsoles (sclerophyll forests) derived from quartzites and red-brown earths (savannah woodland) derived from slates and phyllites; in Eastern Australia conjunctions in the same climatic zones are found of red earth (rain forest) from basalt and podsoles (sclerophyll forest) from sandstones. Furthermore, orographic agencies as rivers, glaciers and, especially in arid climates, wind action, provide different soil types within the same climate which are not related directly to climate and which carry quite different plant communities.

On account of their inclusion of kinds of change other than biotic change under the term succession the unit of Clements and Tansley is more comprehensive than that of European ecologists, and their "association" may include several associations as defined above. How chaotic is the nomenclature of units can be seen in the comparative table given by du Rietz (1930).

It is apparent that most of the difficulties experienced by Australian workers, and also the divergence of views among different ecological schools, is based on vagueness in the concept of succession and its causes. The term succession covers a number of phenomena of multiple origin, and its use is complicated by the fact that it has been applied in different ways to different grades of plant communities. In fact, a succession of communities may take place: (a) owing to soil changes brought about by the species themselves (biotic causes), (b) owing to soil

changes brought about by external agencies (edaphic causes), (*c*) owing to soil changes brought about by the structure of the community (structural causes). These successions lead to three different climaxes or end points—a biotic climax,

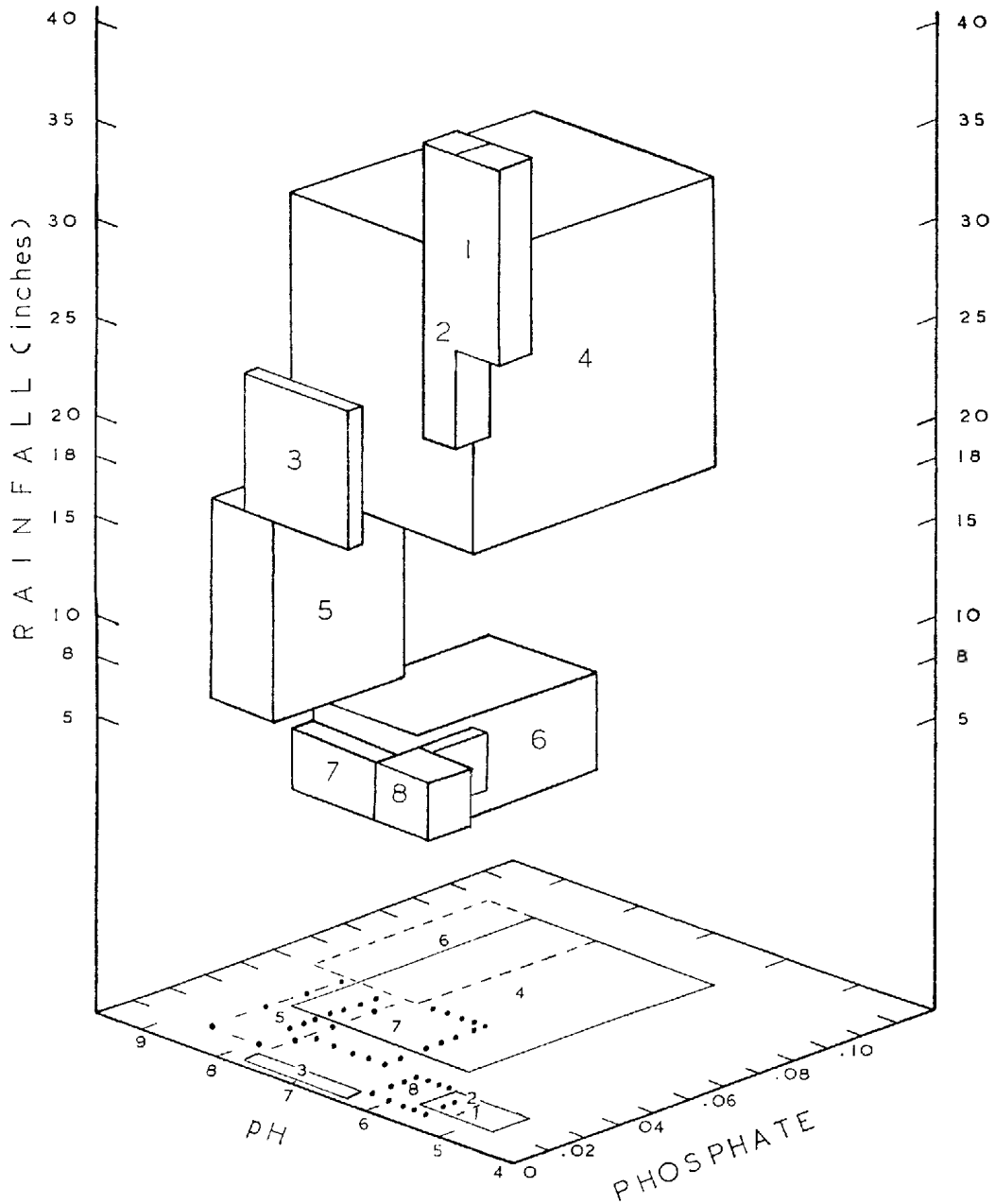


Fig. 2

Three dimensional diagram illustrating relations of plant associations to phosphate (P_2O_5), pH and rainfall.

1, *Euc. obliqua* forest; 2, *Euc. Baxteri*-*Euc. cosmophylla* scrub; 3, *Euc. diversifolia* scrub; 4, *Euc. leucoxyton* savannah woodland; 5, mallee; 6, *Antirrhoea vesicarium* scrub steppe; 7, mulga scrub; 8, *Triodia* desert.

an edaphic climax and a structural climax—within the same climatic zone. Tansley has recognised two types of succession: autogenic or biotic succession and allogenic or succession due to external causes, but all are considered to lead to one climax.

First we may consider biotic succession in which the flora itself may modify the edaphic environment in any climate on any soil, mature or immature. We can distinguish two kinds of biotic succession: first, *primary* on new soils, rock, etc. (lithic succession, etc.); second, *secondary*, due to fire, grazing, etc. The stages in the two types may be different but ultimately lead to one association on any definite soil type.

But the term succession is also applied to include relationships between communities in which a uniform terminal community is *theoretically possible*. There are two main sorts of such theoretical successions. The first includes communities on cliff, steep hill slope, shallow and mature soils in the same climatic zone, *i.e.*, communities on physiographic units. These communities are stable, and each is the end point of a series of biotically induced stages. They are, in fact, associations. Edaphic uniformity could only be attained by the levelling down of all physiographic units to one soil type. The second sort of succession of this kind is that known as zonation as in the distribution of communities around salt lakes, marshes, etc. In this case also uniformity of edaphic environment is only theoretically possible by removal of the factor causing the edaphic zonation in chemical composition.

It is illogical, and from the point of view of field studies, not expedient to group such successions with the biotically induced successions considered above. They may be called *edaphic successions*, and the fact of experience is that we are dealing with a *succession of associations* which culminate in a terminal association which is the edaphic climax association. The series of associations in one climate and on immature soils related to a mature soil type and related floristically form a closely-knit complex which may be called an *Edaphic Complex* and named from the dominants of the edaphic climax association. This unit is the natural unit of complexity above the association.

Within the same climatic zone several such complexes may occur on related or different soil types. These complexes may or may not be closely related floristically. Those complexes which are related floristically can be grouped into larger units. Australian experience suggests that it is desirable to characterise this unit not only by floristic composition but also by life form and structure which in the final analysis are expressions of the characters of the species themselves. It is suggested that the term *Formation* be used for this unit; it is analogous to the formation of Tansley but is not necessarily a climax community.

There remains now for discussion possible succession within edaphic complexes and formations. In South Australia, where the writer has had considerable experience with the plant communities, the edaphic complexes and formations are stable; they are determined in the one climatic zone essentially by soil conditions; and where one complex or formation abuts on to another there is no

evidence of unidirectional invasion of one group by the other. Ecotones may exist between edaphic complexes and oscillations may occur due to local causes, climatic or edaphic. The oscillations are not unidirectional, however, but fluctuating, they are "climax fluctuations" in the sense of Braun-Blanquet.

So far as the writer's knowledge of Australian ecology extends the same is true of all edaphic complexes and formations within the same climatic zone with two exceptions. The exceptions are the unidirectional invasion of eucalypt forest by rain forest on soils of basaltic origin (Fraser and Vickery, 1938; Blake, 1938; and Pryor, 1939) and the invasion of savannah and savannah woodland by brigalow (Blake, 1938).

In these cases the factor controlling invasion appears to be one of integration, primarily concerned with the structure of the communities under discussion. We may consider the case of the rain forest invasion. The Australian plants of the eucalypt forests frequently possess a wide potential environment, for example in South Australia many of the plants of the high forest with an annual rainfall of 40 inches on soils containing .05% P_2O_5 are found also in the mallee-heath with an annual rainfall of 18 inches and on soils containing .005% P_2O_5 (see figs. 1 and 2). As a class they are light demanders and intolerant of shade. Fraser and Vickery (1938) have described the invasion of *E. saligna*-*Syncarpia* forest by rain forest. Even in a relatively closed forest, such as *E. saligna* forms, a considerable amount of light reaches the lower strata; furthermore, whenever a break occurs in the rain forest, *E. saligna* and *Syncarpia* regenerate in large numbers, forming dense thickets of saplings which are gradually replaced by rain forest. At rain forest margins one finds generally the same rain forest species which form a dense cover, killing the eucalypt-forest species by light-competition and gradually by their death enriching the soil with humus, thereby raising its water-retaining capacity and allowing eventually the development of rain forest. This invasion may proceed until the rainfall and humidity limits of rain forest are reached. The invasion of savannahs by dense thickets of brigalow, which also change the soil type, is apparently analogous.

In these cases obviously we are dealing with a biotically induced succession; it differs in degree from those discussed previously by the fact that it is induced primarily by the structure of the community. It would appear then that Clement's concept of the climatic climax is applicable only to highly integrated communities. In lowly integrated communities edaphic factors determine the nature of the climax communities and it may be difficult to describe them by a single name.

In conclusion, one other point should be stressed, this is that it is possible to arrange a succession of "climate climaxes." In the system considered above one factor of the environment, *viz.*, climate, has been made constant. One could also build a system making not climate but edaphic factors constant. As an example one can cite the mallee soils of South Australia, which are constant in profile and in chemical make-up over areas in which the rainfall decreases from 18 inches to 5 inches per annum. On this soil type, and with decreasing rainfall, one sees

TABLE I
Ecological Units with Example from Eucalyptus Forests, High Rainfall Region in South Australia

UNIT	STAGE	ASSOCIATION	EDAPHIC COMPLEX	FORMATION	CLIMATIC CLIMAX
Group relations determined by	Unstable, Soil, flora	Stable, soil, flora	Allied soils, flora	Allied soils, flora structure, life form	Structure
Succession within group determined by		Biota	Soil	Structure	
Example	Lithic, prytic, etc., stages not given in detail for each association.	<i>E. obliqua</i> (edaphic climax)	<i>E. obliqua</i>	Eucalyptus sclerophyll forest	Mixed Eucalyptus forest
		<i>E. Baxteri</i>			
		<i>E. fasciculosa</i>			
		<i>E. stricta</i>			
		<i>E. elacophora</i> (edaphic climax)	<i>E. elacophora</i>	Eucalyptus sclerophyll forest	
		<i>E. fasciculosa</i> (<i>cas. stricta</i>)			
		<i>E. cosmophylla</i> (edaphic climax)	<i>E. cosmophylla</i>	Eucalyptus sclerophyll forest	
		<i>Cas. striata</i>			
		<i>E. diversifolia</i> (edaphic climax)	<i>E. diversifolia</i>	Eucalyptus sclerophyll forest	
		Not fully known			
<i>E. leucoxylon</i> (edaphic climax)	<i>E. viminalis</i> <i>E. obliqua</i> <i>E. leucoxylon</i>	<i>E. viminalis</i> -ecotone	Eucalyptus savannah woodland		
<i>Cas. stricta</i>					
<i>E. odorata</i> (edaphic climax)	<i>E. odorata</i>	Eucalyptus savannah woodland			
<i>Cas. stricta</i>					

a series of communities inter-related floristically and passing from savannah woodland through mallee, tree-steppe and finally shrub-steppe (Wood, 1937). Only by selecting more or less arbitrary climatic zones can definite associations be delimited. Similarly, figs. 1 and 2 show similar relations to rainfall between sclerophyll communities which are characterised by low phosphorus requirements. The reason is that all classifications are arbitrary and designed for convenience. The scheme outlined in this paper accounts adequately for the classification and inter-relations of communities observed in practice. The essentials of the scheme are summarised in Table I.

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OBSERVATIONS ON THE MANDIBULAR TORUS

By FRANK J. FENNER, Honorary Craniologist, South Australian Museum

Summary

Danielli (1884) and Hansen (1895) first described the occurrence of hyperostoses of the lingual surface of the lower jaw in Lapps, Ostiaks, and Eskimos. In 1908, after the examination of the some 400 Eskimo skulls, Fürst described these hyperostoses in greater detail and proposed the term *torus mandibularis* for the formation. He defined the mandibular torus as a bony bulge or series of bulges on the lingual side of the alveolar process of the mandible above the mylohyoid line. Variable in development and extent between the canine and the second molar tooth, it is usually most pronounced opposite the second premolar tooth, and consists throughout of compact bone.

OBSERVATIONS ON THE MANDIBULAR TORUS

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Honorary Craniologist, South Australian Museum

[Read 10 August 1939]

PLATE IX

Danielli (1884) and Hansen (1895) first described the occurrence of hyperostoses of the lingual surface of the lower jaw in Lapps, Ostiaks, and Eskimos. In 1908, after the examination of the some 400 Eskimo skulls, Fürst described these hyperostoses in greater detail and proposed the term *torus mandibularis* for the formation. He defined the mandibular torus as a bony bulge or series of bulges on the lingual side of the alveolar process of the mandible above the mylohyoid line. Variable in development and extent between the canine and the second molar tooth, it is usually most pronounced opposite the second premolar tooth, and consists throughout of compact bone.

Fürst noted that a great development of the torus sometimes occurred in individuals who showed but little tooth-wear, whilst some juvenile skulls also exhibited traces of it. He considered, therefore, that although the torus may originally have been related to tooth wear, it had become a racial character.

Later writers, notably Hooton (1918) and Hrdlicka (1910) stressed the functional origin of the mandibular torus, considering it to be a reinforcement of the alveolar process of the mandible to withstand the strain imposed on it by the rough animal diet of folk living in northern latitudes. A consideration of the strains imposed on the bone of the mandible by vigorous chewing suggests that the mandibular torus would be almost useless as a strut to reinforce the mandible. Hrdlicka also notes that "... its occurrence in infant skulls indicates that at least to some extent the feature is already hereditary in these Eskimo (Southampton Island)."

Campbell (1925), commenting on the absence of this formation in the jaws of Australian aborigines, says, "If, as has been stated by some writers, the mandibular torus is essentially a functional adaptation, its marked absence in the Australian native requires some explanation, for an examination of his dentition must convince one that it would be difficult to find another people whose masticatory habits subjected the dental system to greater stresses than did his." Campbell's more recent publication (1939) on the food habits of the Australian provides abundant support for this statement.

Weidenreich (1936) recently described the occurrence of the mandibular torus in the jaws of *Sinanthropus pekinensis*. This discovery gives the torus a new significance and places further difficulties in the way of any functional explanation. In his monograph on the mandibles of *Sinanthropus* Weidenreich

discusses the various theories of the significance and origin of the mandibular torus. He enlarges the definition of the torus, distinguishing two types: (a) the striation type, consisting of oblique striations running from behind forwards and downwards, and being confined to the region of the molar teeth; (b) the tubercle type, consisting of tubercles of compact bony tissues lying just below the alveolar border, and occurring usually in the region of the premolar and canine teeth.

As there would appear to be some inconsistencies in his discussion of the subject, further comment on Weidenreich's theories may not be out of place. He says of the two types of torus that "... the former (area of striations) is nothing else but a regular and specific differentiation of the posterior rough part, whereas the swellings are to be considered as exaggerated irregularities of the same character occurring occasionally," and that "whereas the tubercle type always occurs in combination with the striation type, the latter may occur independently." Discussing the comparative anatomy of the feature, Weidenreich notes that "the striations of the molar region are very common in the chimpanzee as well as the gorilla," but he "failed to observe anything (in the anthropoids) that could be considered to be in direct relation to the tubercle type of *Sinanthropus*." Summing up his views on the morphology of these structures, "the writer believes that the formation of the striation type of *Sinanthropus* depends on the attachment of the mucous membrane to the surface of the bone." "As to the tubercle type, that is to say the real torus mandibularis, I am inclined to the suggestion that the protuberances are pillars left during the reduction which the formerly much bulkier alveolar process has undergone in the course of human evolution."

It is difficult to reconcile these latter statements with the suggestion that "... the more pronounced swellings of the anterior part (tubercles) are nothing else but a continuation of the elevations of the molar region (striations)." For these reasons, and for others noted in the writer's own investigations, one feels that Weidenreich is in error in including "striations," as well as "tubercles," under the general heading of *torus mandibularis*.

Drenman (1937), stimulated by Weidenreich's discovery, has described the occurrence of the mandibular torus in the Bushman of South Africa. He follows Weidenreich in considering the striations and tubercles to be different types of mandibular torus, but in both his series of Bushman mandibles he notes the occurrence of the tubercular mandibular torus unassociated with the striation type. This is not in agreement with Weidenreich's dictum, "whereas the tubercle type always occurs in combination with the striation type, the latter may occur independently."

It is with Weidenreich's statement that "in all the existing literature no mention is made of its occurrence in Negroes, Malaysians, or primitive races like the Australians, Melanesians, etc." that this paper is particularly concerned.

The results of the present investigation, which are claimed to be significant both in number and variety, are set out in the following table. The writer has here considered only the "tubercle type" as being the *torus mandibularis*.

TABLE I
Incidence of Mandibular Torus
in Australians, Papuo-melanesians and Tasmanians

Race			Total Specimens Examined	Torus Absent	V. Small	Torus Present Small	Medium	Large
Australian	-	-	400	394	3	2	1	—
Papuo-melanesian	-	-	180	171	8	1	—	—
Tasmanian	-	-	18	16	1	—	1	—

Small tubercles were also noticed in the jaws of one Chinese, one "Negro," one Arizona pueblo-dweller, one Lapp, and one ancient Etruscan.

The three mandibles showing the greatest development of the torus mandibularis are illustrated in plate ix, and descriptions of them are set out below.

1. Australian (A46, Australian Museum, Sydney. From Cowra, N.S.W., Male Post-European burial). Pl. ix, fig. 1.

Below the second premolar tooth on the left is a small discrete tubercle of compact bone. Its dimensions are approximately 11 mm. high and 11 mm. long, while the highest point, which stands out 4 mm. from the general contour of the mandible, is 7 mm. below the alveolar edge. The posterior-superior aspect of this tubercle is grooved, apparently for a fine nutrient vessel.

On the right side there is a similar slightly smaller tubercle, and in this case a fine vascular groove runs over the highest part of the tubercle. There is also a very small tubercle just below the right first premolar tooth.

There is some roughening of the alveolar edge just beneath the molar teeth, but nothing sufficiently distinct to be called "striations."

2. Melanesian (A18044, South Australian Museum, Adelaide. From New Caledonia. Male). Pl. ix, fig. 2.

In this mandible there is one small tubercle on the left opposite the interspace between the first and second premolar teeth. Its dimensions are approximately 7 mm. high and 8 mm. long, while the highest point, which stands out 3 mm. from the general contour of the mandible is 5 mm. below the alveolar edge. This tubercle is separated from another very small elevation below the first molar tooth by the groove of a nutrient vessel.

On the right there is a general elevation of bone extending from the canine to the first molar tooth. The bone just beneath the alveolar border in the region of the molar teeth is slightly raised and traversed by several vascular grooves the formation here might fall within the class of striations of Weidenreich.

3. Tasmanian ⁽¹⁾ (A22275, South Australian Museum, Adelaide, from Mount Cameron West, Tasmania. Male). Pl. ix, fig. 3.

This mandible is characterised by bilateral swellings in the region of the canine and premolar teeth. The dimensions of the bulge on the right are approximately 9 mm. high and 14 mm. long, while the highest point, which stands out

⁽¹⁾ Wunderly (1939) considers this skull to be that of a Tasmanian-Australian mixed-blood. Hrdlicka (1928) accepted it as Tasmanian.

3 mm. from the general contour of the mandible, is 7 mm. below the alveolar edge. The torus on the left is of similar dimensions but slightly smaller. There are no striations in the molar region.

The right medial incisor tooth in this jaw is undeveloped, causing a slightly asymmetrical arrangement of the remaining teeth.

Four hundred Australian mandibles were carefully examined to find the frequency of occurrence of the striations. The results are set out in Table II.

TABLE II
Occurrence of Striations and Tubercles in Australian Mandibles

No. of Specimens					Striations	Tubercles	Striations and Tubercles	Nil
400	-	-	-	-	28	6	—	366
Development :								
Very slight	-	-	-	-	15	3		
Slight	-	-	-	-	11	2		
Moderate	-	-	-	-	2	1		
Great	-	-	-	-	—	-		

These figures do not suggest any relation between the striations and the tubercles and do not agree with Weidenreich's statement that "the tubercle type always occurs in combination with the striation type.

Table III shows the distribution of the mandibular torus among various human races, from information obtained from several writers, mainly Weidenreich.

CONCLUSIONS

(1) Weidenreich's differentiation of a "striation" and a "tubercle" type of mandibular torus is open to question, the latter form only being considered to be the *torus mandibularis* of Fürst.

(2) The *torus mandibularis* does occur, although very rarely, among Australian, Tasmanian, and Melanesian mandibles.

(3) While no theories of the morphology of the torus are presented here, it is suggested that the functional hypothesis of Hooton and Hrdlicka is inadequate.

SUMMARY

The literature concerning the mandibular torus is reviewed and the findings of Weidenreich discussed in some detail.

Series of Australian, Melanesian, Tasmanian, and other mandibles have been examined for the occurrence of the mandibular torus.

ACKNOWLEDGMENTS

The writer is indebted to the Board of Governors of the South Australian Museum; to Dr. Anderson, Director of the Australian Museum, Sydney; and to Dr. Clements, Director of the Australian Institute of Anatomy, Canberra, for permission to examine material under their care.

TABLE III

Occurrence of the *Torus Mandibularis* in Man (Tubercle Type only)

Group	Total Percentage	Average as given by the Authors	Authors
Eskimo (Greenland) - - -	85.0		Fürst and Hansen (1915)
Eskimo - - -	87.0		Hooton (1918)
Eskimo (Western):			
Adult Male - - -	79.5	69.7	Hrdlicka (1910)
Adult Female - - -	60.0		
Children - - -	24.2		
Eskimo - - -	97.0		Allen (1890)
Eskimo Male - - -	62.5	41.7	Schreiner (1935)
" Female - - -	33.3		
Ostiak - - -	31.4		Danielli (1884)
Lapp - - -	29.4		Danielli (1884)
Lapp - - -	30.35		Fürst and Hansen (1915)
Lapp: Adult Male - - -	26.8	32.5	Schreiner (1935)
Adult Female - - -	38.8		
Children - - -	12.9		
Icelander - - -	67.9		Hooton (1918)
Ainu - - -	24.0		
Japanese: Neolithic - - -	62.1	9.4	from Weidenreich (1936)
Modern Japanese (Kinai) - - -	14.0		
" Japanese (Kranto) - - -	—		
American Indian (South California) - - -	4.3		Hooton (1918)
Scandinavian: Prehistoric and Middle Age - - -	17.0		Fürst and Hansen (1915)
Later Periods - - -	12.0		
Norwegian: Middle Age Male - - -	24.0	17.0	Schreiner (1935)
Middle Age Female - - -	10.0		
Later Periods: Male & Female - - -		12.0	
Italian - - -	3.3		Weidenreich (1936)
(slight)			
Sinanthropus - - -	50.0		
Chinese: Prehistoric - - -	23.0		
Recent - - -	15.0		
Moravian - - -	2.6		
Bushman: Prehistoric - - -	32.1		Drennan (1937)
Recent - - -	24.0		
Australian - - -	—		Campbell (1925)
Bantu - - -	—		Shaw (1931)
Australian - - -	1.5		Fenner (1939)
(slight)			
Papuo Melanesian - - -	5.0		
(slight)			
Tasmanian - - -	11.0		
(slight)			



Fig. 1
Australian mandible A46
a = tubercles

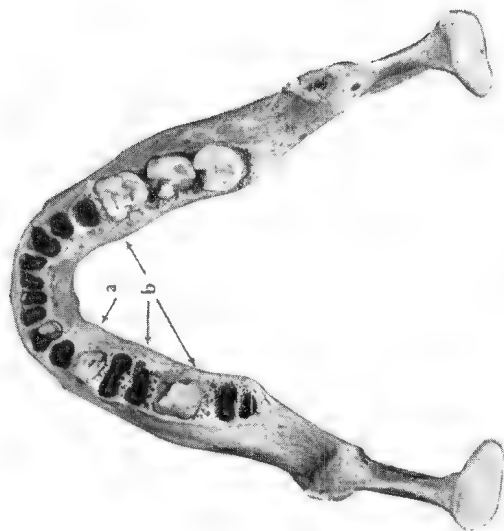


Fig. 2
New Caledonian mandible A18044
a = tubercle. b = striations

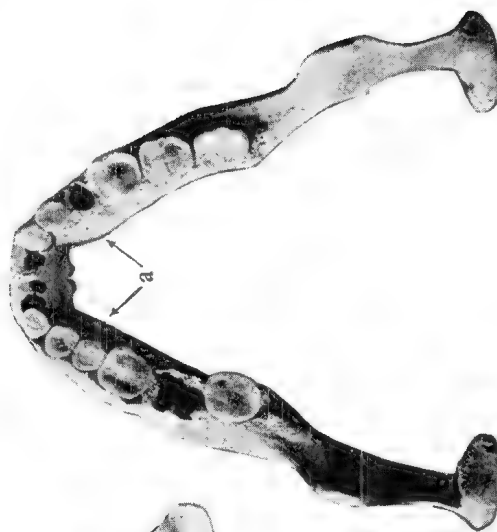


Fig. 3
Tasmanian mandible A22275
a = tubercles

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THE DIPLOSTOMULUM STAGE OF CERCARIA MURRAYENSIS

By T. HARVEY JOHNSTON and E. R. SIMPSON, University of Adelaide

Summary

We described recently (1938) *Cercaria murrayensis* from the pond snail, *Limnaea lcssoni*, taken on several occasions during 1937 and early 1938 at Tailem Bend and Swan Reach, Murray River, South Australia. The relationship to two North American cercariae, and especially to *C. flexicauda* Cort and Brooks, was discussed. The larva was stated to belong to *Proalaria*, it was mentioned that the succeeding stage occurred as a diplostomulum in the eyes of certain freshwater fish.

THE DIPLOSTOMULUM STAGE OF CERCARIA MURRAYENSIS

By T. HARVEY JOHNSTON and E. R. SIMPSON, University of Adelaide

[Read 14 September 1939]

We described recently (1938) *Cercaria murrayensis* from the pond snail, *Limnaea lessona*, taken on several occasions during 1937 and early 1938 at Taillem Bend and Swan Reach, Murray River, South Australia. The relationship to two North American cercariae, and especially to *C. flexicauda* Cort and Brooks, was discussed. The larva was stated to belong to *Proalaria*, and it was mentioned that the succeeding stage occurred as a diplostomulum in the eyes of certain fresh-water fish.

On 16 October 1937 a number of the cercariae were placed in an aquarium with a golden carp, *Carassius auratus*, and additional larvae were added two days later. On 18 and 19 October the fish showed symptoms of disease. On the 20th these were more pronounced, the fish becoming very lethargic and remaining near the surface on the light side of the vessel. It did not respond to a quick movement of the hand, both eyes being markedly protruding and very bloodshot. The carp died on the 21st, and on dissection many metacercariae were found in the lenses of both eyes.

On the 23rd the experiment was repeated with a congolly (*Pseudaphritis urvillii*) and three golden carp (*Carassius auratus*). These fish, immediately after being placed in the tanks with the cercariae, became very active, then afterwards, lethargic. On holding the aquarium to the light hundreds of cercariae could be seen floating. They were not attracted towards the fish, but great numbers were observed entering the mouth passively in the respiratory water current. All these fish died during the night.

On 24 November 1937 a golden carp which had been infected with cercariae in the preceding May, died. Numbers of full-grown diplostomula were seen moving in the outer soft tissues of both lenses. The parasites were able to live for several hours in water, contracting and expanding slowly, but unable to make much progress. The two limbs of the bladder and the intestine, which was filled with refracting granular material, were clearly visible.

In April 1938 some rice fish, *Oryzias latipes* (Schlegel), were placed in infected water and dissected in less than an hour. In many cases, death had already occurred as a result of the great number of penetrating larvae. Numerous tail-less cercariae were found crawling through the body tissues; many were observed in the roof of the mouth, and the gill filaments were commonly suffused with blood. Cercariae were found to have penetrated the gills and the surrounding tissues. They were seen moving along the inner walls of branchial blood-vessels and in the different chambers of the heart. The structures immediately around the eyeball were haemorrhagic, this region containing the greatest number of cercariae. Specimens were seen penetrating the eyeball in the angle between

the cornea and the eyelids, and several were noticed in the aqueous humour, while others were observed in a blood-shot area on the edge of the vitreous humour, and a number had already reached the lens. *Cercaria murrayensis* is thus able to penetrate certain species of freshwater fish through almost any part of the body surface, specimens congregating rapidly around the eyes and finally reaching the lens. Davis (1936b) proved experimentally that blood-vessels afforded an easy path for the progress of related cercariae, hence their rapid distribution through the tissues of the host. In an earlier paper (1936a) he showed that there was present in the body of *C. flexicauda*, a ferment possessing a histolytic action on tadpole skin and muscle. A similar enzyme doubtless occurs in our species and facilitates entry into the host. Direct penetration of the eye through the cornea was not observed, but may have taken place, though sections did not afford any positive evidence. La Rue, Butler and Berkhout (1926) stated that penetration through the cornea by allied forms was first observed by Steenstrup in 1842 and confirmed by later workers.

If the parasites enter in too great numbers they interfere with the sensitivity of the fish and soon cause its death. If present in smaller numbers we ascertained that they will develop in about six weeks into full-grown diplostomula in the lens. Mr. G. Jaensch (who has generously assisted us in regard to material) has reported that golden carp, up to six inches long, when placed in a tank at his home at Tailem Bend with infected *Limnaea lessoni* died within 48 hours, while specimens of the Murray bream, *Therapon bityana*, of similar length, remained apparently unaffected.

In addition to the fish already mentioned, *Melanotaenia nigrans* and *Pseudomugil signifer* have been successfully infected in the laboratory.

We noted that all small fish brought from the Murray River to Adelaide in receptacles containing *Limnaea* which were emitting abundant cercariae (*C. murrayensis*) were dead by the following morning. Such fish included golden carp, *Nannoperca australis*, *Galaxias olidus*, congolly (*Pseudaphritis urvillci*) and callop. Natural infection, always slight, was found in the lens of larger specimens of golden carp, Murray cod (*Maccullochella macquariae*), callop (*Plectroplites ambiguus*) and Murray bream (*Therapon bityana*), all from Tailem Bend.

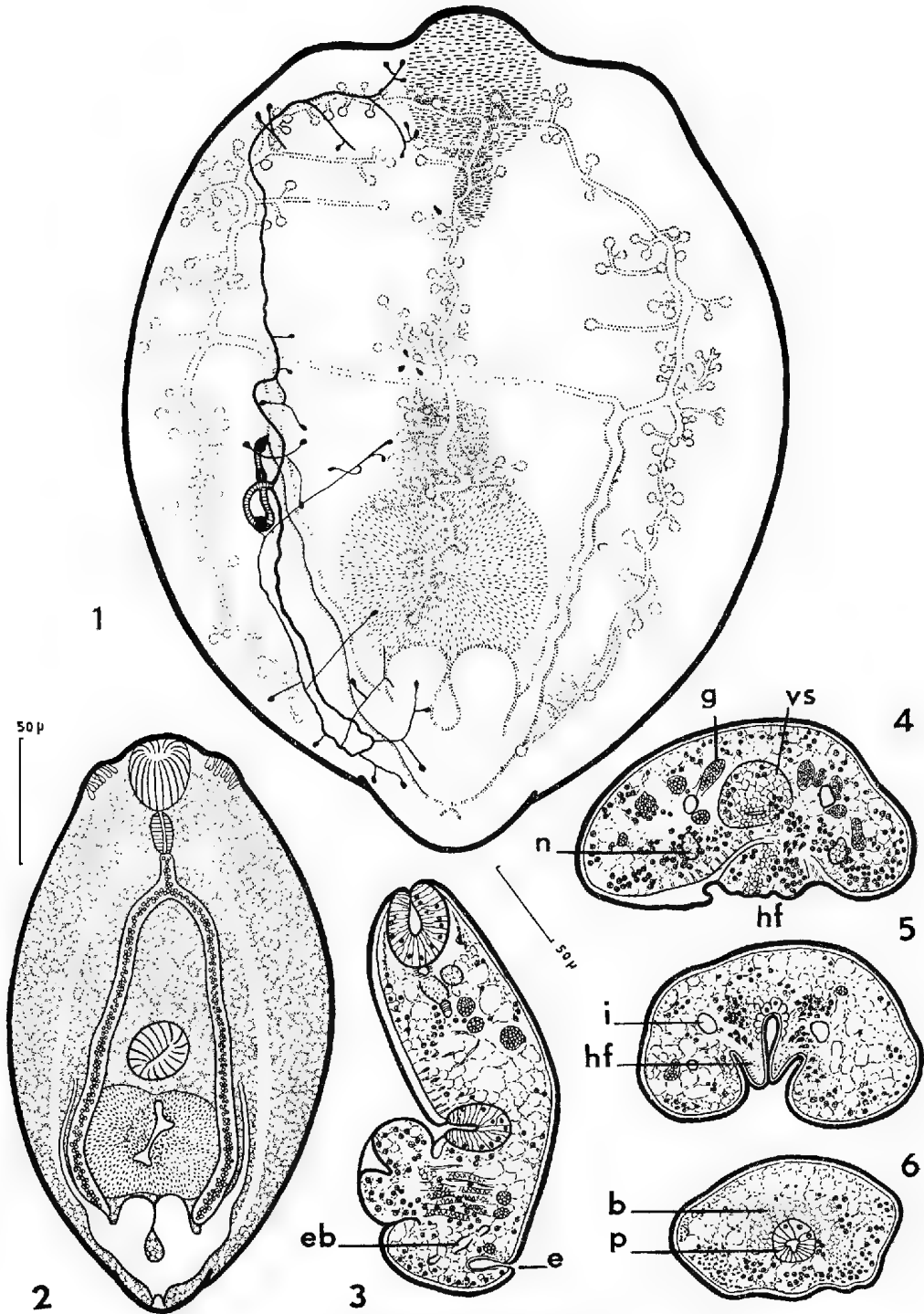
The snail host lives in the quiet water of the swamp, feeding on vegetation growing in depths of a few feet. It is in such situations that small fish find their food and protection and no doubt become infected by cercariae. Heavy infestations could occur if such fish swam through a mass of these larvae, and such fish would be either killed or disabled and thus likely to be taken by various fish-eating birds which are well represented in such swamps.

Small fish infected artificially with diplostomula were fed to laboratory-bred white rats and to muscovy ducklings in an endeavour to obtain the adult stage, but the results were negative. As a result of our further study we now believe that the diplostomulum will be found to reach maturity in gulls or terns, most probably *Larus novaehollandiae*. This question will be discussed later in the present paper.

The diplostomulum possessed a thin leaf-like fore body and a small dorsal hind body. The mouth, just below the tip on the ventral surface, was surrounded by the anterior sucker. A short prepharynx and a muscular pharynx were present. The small oesophagus bifurcated into two well-defined caeca filled with a highly refractive flocculent substance and ending blindly at the level of the anterior part of the excretory bladder. Two lateral suckers normally formed a slight swelling, one on either side of the anterior sucker, but could be retracted each into a cup-shaped depression. The ventral sucker, at the beginning of the second half of the body, lay just in front of the large holdfast organ consisting of a raised margin surrounding an irregular concavity. This pit, lined with cuticle bearing minute spines, was supported by a few large clear cells, and the tissue surrounding it contained small dark-staining nuclei (figs. 4, 5).

The brain (fig. 6) consisted of two cerebral masses connected dorsally by a wide commissure. An anterior nerve was traced forwards for a short distance, and a posterior nerve as far back as the excretory bladder. Granular unicellular glands were seen scattered throughout the body and opening directly on the surface. A small group of them was present in the base of the anterior sucker. The reproductive system was represented by a group of cells lying mesially, posterior to the holdfast organ. Transverse and longitudinal muscle fibres could be seen readily in living specimens and were strongly developed on the ventral surface just anterior to the holdfast organ.

The excretory bladder consisted of two ventro-lateral halves connected by a dorsal median portion opening dorsally on the hind body (figs. 2, 3). The main vessels (fig. 1) arose from the lateral margins of the two halves of the bladder and continued forwards until just in front of the level of the ventral sucker. With them were connected both the primary and secondary excretory systems. The main tube of the former arose at the level of the posterior margin of the ventral sucker and was somewhat J-shaped. It contained three ciliated areas. Its short stem divided into an ascending and a descending tubule. The latter passed posteriorly almost beyond the bladder, then was directed forwards and gave rise to flame cells, usually in groups of three. The anterior tubules travelled forwards and appeared to end alongside the anterior sucker. The flame cells and their connections seen by us are indicated in fig. 1. In the study of the cercaria stage we were unable to observe ciliated areas corresponding to those in the main tube of the primary excretory system of the diplostomulum, but this may have been due to the large penetration gland cells obscuring their presence. In the secondary excretory system a transverse canal connected the two main excretory ducts just in front of the ventral sucker. From this canal arose on each side an ascending and a descending branch, the latter terminating at the level of the bladder, the former becoming continuous near the anterior sucker with its fellow from the opposite side and with a vertical median branch passing back to join the transverse canal. From the latter also arose a median posterior tubule lying above the region of the ventral sucker and holdfast organ. The calcareous concretions associated



Diplostomulum murrayense

Fig. 1, Compressed specimen, showing excretory system; 2, dorsal view; 3, longitudinal section; 4-6, transverse sections. All drawings except fig. 1 were made with the aid of a camera lucida; figs. 3 to 6 were drawn to the scale beside fig. 3. b, brain; e, excretory pore; eb, part of excretory bladder; g, unicellular gland cells; hf, holdfast organ; i, intestine; n, longitudinal nerve cord; p, pharynx

with these tubules were circular in outline, and were found to vary in size in one specimen, and in number and arrangement in different diplostomula. Blind branches of the tubules were sometimes noticed containing no concretions.

The following are the measurements of ten diplostomula killed by adding to the water containing them an equal volume of boiling 10% formalin: length of body $231\text{ }\mu\text{--}392\text{ }\mu$, mean $296\text{ }\mu$; breadth of body $154\text{ }\mu\text{--}215\text{ }\mu$, mean $177\text{ }\mu$; length of anterior sucker $22\text{ }\mu\text{--}43\text{ }\mu$, mean $34\text{ }\mu$; breadth of anterior sucker $42\text{ }\mu\text{--}51\text{ }\mu$, mean $47\text{ }\mu$; length of ventral sucker $30\text{ }\mu\text{--}37\text{ }\mu$, mean $34\text{ }\mu$; breadth of ventral sucker $34\text{ }\mu\text{--}47\text{ }\mu$, mean $39\text{ }\mu$; length of holdfast organ $71\text{ }\mu$; breadth of holdfast organ $79\text{ }\mu$.

In the original account the cercaria was stated to be closely related to an American form, *C. flexicauda* Cort & Brooks (1928), whose later stages were investigated by Van Haitsma (1931). He showed that the diplostomulum developed in the crystalline lens of a freshwater fish and had been described by Hughes and Berkhout in 1929 as *D. gigas*. Van Haitsma gave an account of the adult stage obtained experimentally from North American gulls and compared it with the related species, *Diplostomum huronense* (also from American gulls) and *D. spathaceum* from European gulls.

Cercaria murrayensis is obviously very closely related to *C. helvetica* XIII of Dubois (1929; 1938), i.e., *Cercaria* C. of Szidat (1924; 1927) which develops into *Diplostomulum volvens* Nordmann in the lens of certain European fish and later, in gulls, into *Diplostomum spathaceum* (Rud.). The two cercariae differ chiefly in the number and arrangement of the "caudal bodies." Dubois (1938, 178) refers to several species of related cercariae, the adults (where known) occurring in gulls.

The diplostomulum described in this paper shows, as one would expect from the foregoing remarks, considerable similarity to *D. huronense* as described by Hughes and Hall (1929), *D. brozeni* Hughes (1929), *D. gigas* Hughes and Berkhout (1929) (i.e., *D. flexicaudum*), and to some described by Van Cleave and Mueller (1934, 238-245) from the eyes of freshwater fish in New York State. The resemblance is closest to *D. brozeni* and *D. gigas*. The average length and breadth of *D. murrayense* lie about midway between those of these two North American species; but the holdfast organ is much larger in relation to body-length and the sucker ratio is 1.2, whereas it is 1.03 in *D. brozeni* and 1.06 in *D. gigas*. Cort and Brackett (1937) recorded the occurrence of precocious development of *D. flexicaudum* in the species of pond snails (*Limnaea* spp.) in which the cercaria stage is produced. Hughes (1929), Van Haitsma (1931) and Dubois (1938) have indicated that La Rue's (1926) name *Proalaria* as applied to the *spathaceum* group of Strigeidae must be suppressed in favour of *Diplostomum*, originally applied by Nordmann to a larval stage (*D. volvens*), the term *Diplostomulum* being reserved for the metacercaria stage occurring in the eyes of fish.

La Rue, Butler and Berkhout (1926) gave a concise survey of the recorded occurrences of strigeid larvae in the eyes of freshwater fish in Europe and North

America. They also published a list of fish found to be infected naturally in Lake Michigan, together with the degree and percentage of infection. Nordmann (1832) is reported to have found *Diplostomum volvens* so abundant in the eyes of freshwater fish in Europe during the summer as to cause cataract. This parasite is now known to be the larva of *D. spathaceum* and is very closely related to *D. murrayense* which appears to be its Australian representative. Steenstrup (1842) was the next to refer to similar occurrences of such trematodes. Salzer (1907) gave an account of the pathogenic effects of *D. volvens* on the lens of trout. Blochmann (1910) referred to the death of various kinds of aquarium fish due to invasion, both natural and experimental, of *Cercaria fissicauda* Val. (which is probably the larva of *D. spathaceum*).

Szidat (1924) gave an account of his *Cercaria C.* which he showed, developed into *Diplostomum volvens* in the eyes of freshwater fish and later into the adult stage in European gulls. The effect on fish was to produce more or less turbidity in the lens, but when the invasion was too heavy death was caused. Entry took place through the body surface, but the scales and bones limited the penetration into the soft tissues; the brain, blood-vessels and other organs were invaded for a short time, but the final destination in the fish was the eye, chiefly the lens.

In 1926 Ward and Mueller described a "pop eye" disease of trout fry. Next year Szidat (1927) gave an account of mortality of *Acerina* and *Leuciscus* due to marked cerebral haemorrhages caused by the penetration of the furcocercaria. In 1928 Cort and Brooks in describing *C. flexicauda* and some others mentioned that these larvae were able to penetrate into fish and became localised in the lens as *Diplostomum*. Hughes and Berkhout (1929) reported that *D. gigas* (closely related to *D. spathaceum*), which infests the lens of North American fish, caused impairment of vision, heavily infected lenses becoming flaccid and mis-shapen, the digestive system of the diplostomula containing a highly refractive granular substance derived from the lens material.

Haitsma (1931) traced experimentally the complete life cycle of *C. flexicauda*, showed that *D. gigas* was a synonym of *D. flexicaudum* and that the latter was closely related to, but distinct from, *D. spathaceum* from European gulls. He gave an account of the pathology of the invasion of fish eyes (p. 507-510), the parasite (when invading in great numbers) being regarded as an important cause of mortality amongst freshwater fish in North America. Davis (1936b) studied the penetration of *C. flexicauda* into fish and tadpoles through the general surface, thence into the blood-vessels, heart, brain, eyes, muscles, liver, gills, kidney and digestive tract; death being caused by haemorrhages, though paralysis (due to invasion of the nerve centres) was at times contributory. Davis (1936a) also showed that the cercaria produced a histolytic ferment which permitted penetration of the tissues of the host.

The adult stage of *Diplostomum murrayense* will almost certainly be found to be a parasite in the rectum or cloaca of a lariform bird, most probably the silver gull, *Larus novae-hollandiae*. Some strigeids are known from Australian gulls and terns but, as yet, no species of *Diplostomum* (s. str.) has been reported

from them, though Krull (1934) obtained *Neodiplostomum pricci* from *Larus novae-hollandiae* (bred in Washington D.C., U.S.A.) by experimental feeding with fish containing metacercariae; the adult form was transferred to *Mesophora diplostomum* by Dubois (1936) who has since recorded it (1938) as a parasite of a North American gull, *Larus delawarensis*.

Grateful acknowledgment is made of generous assistance given by Messrs. G. and F. Jaensch, of Tailem Bend. Our work was made possible by a research grant from the Commonwealth to the University of Adelaide.

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A NEW SPECIES OF THE FAMILY NEPTICULIDAE (LEPIDOPTERA)

By J. O. WILSON

Summary

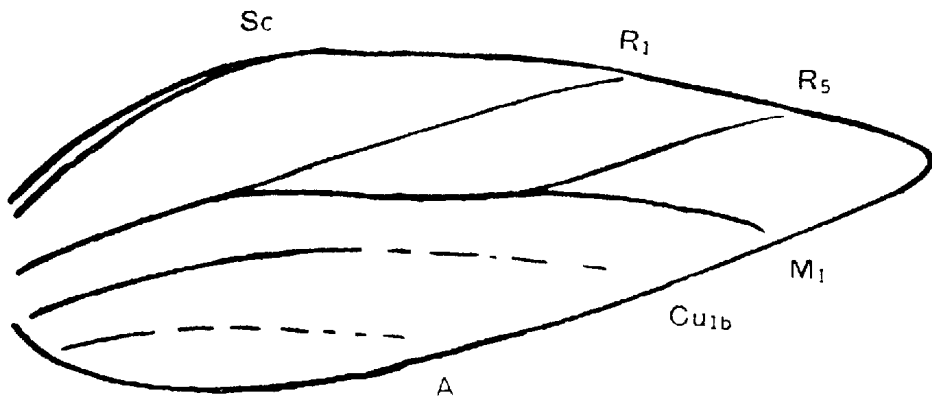
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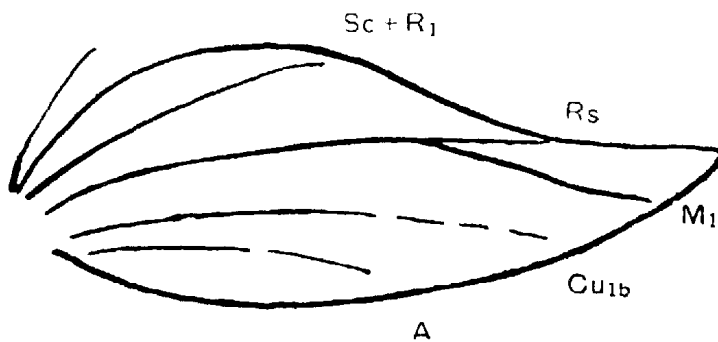


Fig. 1

The Nepticulidae are generally easy of recognition by the rough-haired head, the large scape which is concave beneath and forms the cyccap, and the neuration which is much degraded and of peculiar construction.

The larvae, so far as is known, are all leaf miners, usually pupating outside the mine.

The material for this paper, which comprises four examples of the following species, was taken by the University of Adelaide Anthropological Expedition to the Warburton Ranges in August, 1935. As these specimens were dry and there was little hope of successful setting, three have been mounted on cover glasses—which allows inspection from all angles—and the fourth used for dissection.

***Nepticula warburtonensis* n. sp**

♂, ♀, 3-4 mm. Head yellowish-ochreous. Antennae $\frac{2}{3}$, ochreous. Eyecap whitish-ochreous, large and smooth. Thorax ochreous. Patagia pale ochreous posteriorly with brown-black scales. Forewings lanceolate, costa arched then straight to apex, pale ochreous, irrorated throughout with brownish-black scales. Vein R_4 absent or coincident with R_5 . Cilia pale ochreous with scattered brownish-black scales near apex. Hindwings lanceolate with costa arched then concave to apex, light fuscous, cilia light fuscous.

Four specimens, coll. Wilson. No. 1 type, Nos. 2 and 3 paratypes, No. 4 dissected.

The evidence obtained from a study of descriptions of known Australian species indicates a close association superficially with *N. chalcitis* Meyr., from Western Australia. Detailed anatomical studies of many of the species is, however, lacking, and therefore correlation as to form and especially neurulation must stand in abeyance.

ACKNOWLEDGMENTS

Many thanks are due to Professor M. L. Mitchell, University of Adelaide, for use of special microscopic apparatus; also Dr. Hackett of the University Anthropological Expedition, and to Mr. Womersley and Mr. N. Tindale of the South Australian Museum, for help and criticism.

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ADDITIONS TO THE FLORA OF SOUTH AUSTRALIA

NO. 38

By J. M. BLACK, A.L.S.

Summary

SCHIZAEACEAE

Schizaea dichotoma (L.) Sm. In drying swamp inland from Tunkalilla Beach; Dec. 1938, J. B. Cleland. A new record for South Australia. Also in New South Wales, Queensland, New Zealand and tropical Asia and America. Small specimens, the leaves 9-12 cm. long, 2-5 times dichotomously divided, the segments about 1 mm. broad and slightly channelled.

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GRAMINEAE

Panicum Whitei J. M. Black, in Trans. Roy. Soc. S. Aust., 41:632, t. 39 (1917), and pl. i, Fl. S. Aust., 59 (1922). Differs from *P. decompositum* R. Br. in panicle-branches slender, not rigid, the lowest one always solitary and the upper ones either solitary or in pairs or threes, the leaf-sheaths, or at least the upper ones, beset with long spreading hairs seated on tubercles, and the fruiting glume more prominently nerved. *P. decompositum* is glabrous; the panicle-branches are rigid and brittle, and the lower ones are clustered or whorled round the rachis.

A type-specimen of *P. Whitei* was submitted in 1917 to the late Dr. O. Stapf, then principal agrostologist at Kew, who at first accepted it as a new species, but subsequently decided that it was a form of *P. decompositum*, and his opinion was followed by me in the Fl. S. Aust. S. T. Blake, of the Biology Department of the University of Queensland, has recently found *P. Whitei* growing in the districts of Western Queensland, north of our border, where it is known as Pepper Grass or Pigeon Grass. He considers that the two species are quite distinct in the field and in the herbarium.

In South Australia *P. Whitei* has been collected on Cooper and Strzelecki Creeks, 1916, *S. A. White*; Pandie Pandie, on Diamantina River, 1934, *J. B. Cleland*, and at Cootanoorina, W. of Warrina (Tate Herbarium as *P. effusum*). *P. decompositum* is common in our far-northern and north-eastern districts. In Queensland, according to Mr. Blake, it is called Star Grass or Windmill Grass; E. Breakwell, in his "Grasses and Fodder Plants of New South Wales," gives it the name of Native Millet.

Amphibromus recurvatus J. R. Swallen. Vivonne Bay, K.L., "in swamp," Dec. 1934, *J. B. Cleland*. First record for the island. Hitherto this species has only been found in Tasmania and in our South-East.

Zoisia Matrella (L.) Merrill. Robe, Jan. 1938, *Miss C. M. Eardley*. First record outside Kangaroo Island.

**Schismus arabicus* Nees. Marree, Aug. 1932, J. B. Cleland. Determined by C. E. Hubbard, of Kew.—Western Asia and North Africa.

Scarcely differs externally from **S. barbatus* (L.) Juel (*S. calycinus* (Loefl.) Coss. et Dur.), but the flowers are different. The flowering glume is oblong-lanceolate, $3\frac{1}{2}$ mm. long, and divided to one-third, or almost to the middle into two acute lobes, and the palea is only about two-thirds as long. In *S. barbatus* the flowering glume is broadly ovate, 2 mm. long, and is divided to about one-sixth of its length by a short notch, with two short sub-obtuse lobes, and the palea is as long as the flowering glume. *S. arabicus* has only been found at Marree; *S. barbatus* is distributed all over our dry North.

Perotis rara, R. Br. var. *curyphylla*, Domin. Macdonald Downs, C.A., March 1936. Miss Jean Chalmers. Recorded in these Transactions 62:352 (1938) as *P. indica* (L.) O. Kuntze. Mr. C. E. Hubbard, to whom a specimen was submitted, considers that *P. rara* is distinguished from the Indian species by longer outer glumes, narrower leaf-blades and looser spikes. Glume I is about 7 mm. long (without the long awn), and glume II is about 5 mm. long, while in *P. indica* the length of the glumes is $1\frac{1}{2}$ - $2\frac{1}{2}$ mm. In the var. *curyphylla* the leaves are relatively broader (3-4 mm. broad) the outer glumes scabrous-ciliate on the midnerve.

Stipa

Stipa tenuiglumis Hughes. Kingscote, Rocky River; Eleanor River (all Kangaroo Island), J. B. Cleland. Some of these island specimens have very slender stems and leaf-blades, glume I only about 10 mm. long and glume II about 7 mm. long, the awn very slender and the column about 15 mm. long. Among our numerous specimens from the southern parts of the State I find it impossible to distinguish satisfactorily *S. compacta*, Hughes from *S. tenuiglumis*.

S. effusa Hughes. Resembles *S. tenuiglumis*, but is placed by Miss Hughes in section *Aphanoncurae* because of the very short lateral nerves of glume I. Nodes brown, glabrous, usually 3-4 on the glabrous stem; glume I about 9 mm. long, sub-3-nerved; glume II 7-8 mm. long, sub-5-nerved; flowering glume 5 mm. long, including callus of about 1 mm.; awn very slender, 4-5 cm. long; column about 1 cm. long; bristle straight.

Overland Corner (River Murray); Moolooloo, Hawker (Flinders Range). The type came from Lachlan River, New South Wales. A new record for South Australia.

S. variegata Summerhayes et Hubbard is in the description distinguished from *S. pubescens* R. Br., by the column of awn only about 1 cm. long, but an examination of a co-type from Sandergrove, near Lake Alexandrina, retained by Professor Cleland, shows that the column is 2 to $2\frac{1}{2}$ cm. long, just as in *S. pubescens* R. Br. and *S. eremophila* Reader. In our specimens of the latter species the column varies from 2 to 3 cm. in length, and in *S. pubescens* from 2 to $4\frac{1}{2}$ cm.

An exactly similar specimen was collected at Sandergrove by O. E. Menzel some 40 years ago, but the flowering glume is riper and golden-pubescent, so that

S. variegata appears to be a form of *S. eremophila*, of which it has also the rather loose panicle, 10-30 cm. long.

There is little to distinguish *S. pubescens* from *S. eremophila*, except that the latter species has a looser panicle and its flowering glume becomes, when ripe, pubescent with golden or reddish-brown hairs, while that of *S. pubescens* remains white-pubescent. But some specimens have only the callus golden-pubescent, while the flowering glume proper is whitish. Bentham considered specimens of *eremophila* as a form of *pubescens*. A co-type of *S. eremophila*, collected by Reader at Borung, Victoria, has glume I 18-21 mm. long and glume II 13-15 mm., while Miss Hughes records, in Kew Bull., 1922, p. 18, a specimen of *S. pubescens* with glume I only 14-15 mm. long.

Stipa hemipogon Benth. Leaves chiefly basal, the long blades erect, filiform-involute, the sheaths more or less pubescent; ligule short, ciliate; nodes pubescent; panicle dense, narrow, 20-30 cm. long; glume I 14-15 mm. long, 3-nerved; glume II 13-14 mm. long, sub-5-nerved; flowering glume 6 mm. long (including callus of 2 mm.), white-pubescent; awn about $5\frac{1}{2}$ cm. long, the column 16-17 mm. long, unilaterally plumose, the long hairs continued along one side of the bristle for about half its length. (Fig. 3.)

Minnipa, E.P., Nov. 1915 *J. M. B.* A new record for South Australia. The type came from Western Australia. Our specimens have a longer panicle and rather longer awns than in the typical description.

S. bigeniculata Hughes, which was recorded in Fl. S. Aust., 671, should be deleted for this State, as the plants thus named have proved, on a closer investigation of our specimens of this difficult genus, to be chiefly referable to *S. aristiglumis*.

CYPERACEAE

***Schoenus racemosus* n. sp.** Rhizoma repens, squamis duris brunneis nitidis striatis obtectum; culmi teretes, simplices, enodes, rigidi, erecti, 12-30 cm. longi, 1 mm. diam.; folia non evoluta, prope basin culmi sita, inferiores squamis rhizomatis subsimiles, 1-2 summae clausae, arctae, ore dense lanato-barbatae, in laminam brevissimam (5-10 mm. longam), rigidam, subulatam desinentes; inflorescentia racemosa, angusta, densa, 2-4 cm. longa; bracteae 3-4 (raro 1-2), folio summo subsimiles, pedicellos breves erectos singulos usque quaternos suffulcientes; spiculae 1-10, fusco-brunneae, anguste lanceolatae, 9-13 mm. longae, 2 mm. latae, 1-florae; glumae margine dense ciliato-lanatae, inferiores vacuae 3-4, mucrone $2-2\frac{1}{2}$ mm. longo praeditae; gluma florifera 7-8 mm. longa, acuminato-cuspidata; supra florem sunt plerumque 2 glumae vacuae, summa tabescens; stamina 3; antherae lineares, connectivo in appendicem brevem rubram producto; nux alba, obovoidea, obscure trigona, transversim rugosa, 2 mm. longa; setae hypogynae nullae. (Tab. x, fig. 1.)

S. Aust.—Koonibba, E.P., Aug. 1928, *J. B. Cleland*; Chance's Line (on reserve 7 miles south-east of Hartley and near Lake Alexandrina), Oct. 1938, *J. B. Cleland*.

Mr. S. T. Blake, of the Queensland University, who is revising *Cyperaceae*, has kindly assisted me in the elucidation of this species. He writes: "The species is to be placed in the section *Nudicaules* recently proposed by Kükenthal, which is characterised chiefly by the reduced leaves, the racemose or semipaniculate inflorescence, the usually ciliate margins of the glumes and the usually nodeless stems. (It is part of Bentham's series *Paniculatae*). The other South Australian species belonging to the section are *Sch. laevigatus* W. V. Fitzg. (1903-4) = *Sch. brachyphyllus* F. v. M. (1875) and *Sch. carsei* Cheeseman (1906) = *Sch. monocarpus* Black (1928), the former of which has mostly 1-noded stems and much more obtuse glumes, while the latter has glabrous glumes and a smooth nut. The nearest ally appears to be the Western Australian *Sch. caespitius* W. V. Fitzg., which, according to the description, has a similar inflorescence, woolly orifice to the leaf-sheaths, and rugose nuts, but differs in the caespitose habit, more numerous glumes and the presence of hypogynous bristles." Mueller's name of *brachyphyllus* is much earlier than Fitzgerald's but Blake considers that Mueller's short differentiation in Fragn. 9:29 does not constitute a valid publication.

Schoenus deformis (R. Br.) Poir.—Cape Spencer, Y.P., April 1936, J. B. Cleland. A new locality.

LILIACEAE

Lomandra sororia (F. v. M.) Ewart. Leaves 15-30 cm. long, filiform, striate, scabrous, scarcely 1 mm. broad; flowers erect, in a short dense raceme 2-3 cm. long, the males subsessile, the females on short peduncles; segments acute or acuminate, the male ones about $2\frac{1}{2}$ mm. long, the filaments broad and those opposite the inner segments are adnate to them; female perianth $3\frac{1}{2}$ -4 mm. long.

Mount Lofty; Chain of Ponds; Carey's Gully.—Victoria; New South Wales; Queensland.

Stems very slender, less rigid, and in

ERRATUM

In line three of description of *Schoenus racemosus* insert "vaginae" before "inferiores."

along road from Cape Jervis to new locality.

Restio complanatus R. Br. Slender specimens with few spikelets; perianth of four segments in both sexes, all the male segments narrow, the two outer ones of the female flowers narrow, folded and keeled, the two inner ones broad and flat; capsule flat, opening along the margins, 2 mm. long by $2\frac{1}{2}$ mm. broad, 2 celled, or one cell sometimes abortive, seeds ovoid, white $1\frac{1}{2}$ mm. long. Differs from the following in the stems flattened, 2-3 mm. broad, and in the absence of barren branches proceeding from the stem. According to Mueller the stems in eastern specimens vary from 2 to 6 mm. in breadth.

Bulls Creek, Flinders Chase, K.I., Dec. 1934; J. B. Cleland.

Restio tetraphyllus Labill. Stems stiff, slender-cylindrical, with sheathing bracts appressed, becoming brown, 1-2 cm. long, the middle bracts producing

filiform much-divided barren branches 10-15 cm. long, the barren branchlets with minute distant leaves or scales, of which the sheaths and subulate blades are each about 2 mm. long.

Sphagnum bog near Millicent; March 1939; *R. L. Crocker*—Both species occur also in the eastern States and Tasmania. They have been previously recorded from our South-East, but these appear to be the first herbarium specimens known in South Australia.

PROTEACEAE

Grevillea muricata n. sp. Fruticulus; ramuli rigidi foliaque juvenilia pubescentes; folia adulta dense muricata, glabrescentia, alterna, patentia, teretia, rigida, obtusa, mucronulata, 7-10 mm. longa, $1\frac{1}{2}$ mm. diam., subtus 1-sulcata, marginibus arcte revolutis paginam inferiorem lanatam tegentibus; flores axillares, saepius solitarii; pedicellus 3-5 mm. longus, duabus bracteis minimis suffultus; perianthium rubellum, dense tomentosum, tubo 9-10 mm. longo, superne angustato, inferne ampliato, intus puberulo et pilis deflexis prope basin circumbarbato, limbo recurvo, globoso; torus fere rectus, ovarium villosum, brevissime slipitatum; glandula hypogyna inconspicua, annularis; stylus 18-20 mm. longus, omnino pilosus, disco stigmatico laterali; fructus ovoideo-oblongus, circa 12 mm. longus, tomentosus. (Fig. 4.)

Between Vivonne Bay and Kingscote, Nov. 1924, *J. B. Cleland*; Birchmore Lagoon and near Western Cove, K.I., Nov. 1886, *J. G. O. Tepper*.

The leaves have the same muricate surface as in *G. Rogersii* Maiden, but differ in shape, being terete, obtuse with a short point, longer and not clustered. The flowers differ in the densely tomentose perianth and style, the almost straight torus and the annular hypogynous gland. It should probably be placed in section *Ptychocarpa*.

Grevillea aspera R. Br. Specimens from Wilpena Pound, at first collected without flowers, were mistakenly determined by me in these Trans. 61:242 (1937) as *G. alcoides* Sieb. When flowers are present *G. aspera* can be recognised by its very short, thick, clavate style, only 4-6 mm. long. The leaves in some specimens are devoid of the wart-like asperities which gave the species its name. Although usually 3-7 cm. long by 2-4 mm. broad, some of the leaves in northern specimens are 10 cm. long and 10 mm. broad.

POLYGONACEAE

Rumex dumosus A. Cunn. Iron Knob, E.P.; Nov. 1936; *J. B. Cleland*. A new locality.

LEGUMINOSAE

Acacia confluens Maiden et Blakely in Journ. Roy. Soc. N.S.W., 60:183, t. 16, figs. 1-7 (1927).

The first reference to this plant is in Trans. Roy. Soc. S. Aust., 22:109 (1898) in "A list of plants collected on Mount Lyndhurst Run by Max Koch"

(the determinations being by J. H. Maiden and R. Tate), as follows: "*Acacia retinodes* Schlecht., Wattle. Aboriginal name, *Wecrilda*."

Some 19 years later Maiden described it as a new species, adding: "*Wyrilda* of the Mount Lyndhurst blacks, by whom the seeds are eaten (Max Koch, No. 48)."

By the courtesy of the Curator of the National Herbarium, Sydney (Mr. R. H. Anderson) I have seen the type, which has not been re-discovered during the past 40 years. The thick pod and the long and distant peduncles (12-18 mm. long) show an external resemblance to those of *A. salicina*, but the flowers and funicle are those of *A. retinodes*. The pods are 10-20 cm. long, or rather more, 8-10 mm. broad, while the longest I have seen on our southern specimens of *retinodes* are 15 cm. long and 6-7 mm. broad. Benthani, however, describes the pod of *retinodes* as 3-8 inches by 3-4 lines ($7\frac{1}{2}$ to $20\frac{1}{4}$ cm. long by 6-8 mm. broad). *A. confluens* may be merely a thick-podded form of *A. retinodes*.

Acacia gracilifolia Maiden et Blakely, l.c. p. 191, t. 18, fig. 9-14 (1927), also lent for examination, has not been collected since its original discovery by our late Conservator of Forests, Mr. Walter Gill, in 1900 in the Flinders Range (no exact locality). It somewhat resembles *A. Menziesii*, but the phyllodes are more slender, longer, frequently curved and appear to droop. The flowers have almost all fallen; the common receptacle or summit of the peduncle is about 2 mm. long, so that the species appears to be one of those intermediate between the globular-headed and spicate-headed Acacias. Both species were shortly described in Fl. S. Aust., 688.

Gastrolobium elachistum F. v. M. Fragn. 9:67 (1875) = *Pultenaea cymbifolia*, J. M. Black in Trans. Roy. Soc. S. Aust., 39:96, t. 10 (1915). Mr. C. A. Gardner, during his stay at Kew, observed that the specimens under these two names were indistinguishable. This is confirmed by the examination of a specimen of *G. elachistum*, from "Eucla, S.A., Oliver" (no date), presented to the Tate Herbarium by Mueller. As far as now known its distribution is: Kangaroo Island (between Kingscote and Cassini); near Eucla on the Great Bight, and westward to Israelite Bay and Salmon Gums in Western Australia.

STERCULIACEAE

Gilesia biniflora F. v. M. Fragn. 9:42 (1875) = *Hermannia Gilesii*, F. v. M. l.c.; Fl. S. Aust., 693 (1929); *Corchorus longipes*, Tate in Trans. Roy. Soc. S. Aust.; 22:119 (1898); *Hymenocapsa longipes* (Tate) J. M. Black in Trans. Roy. Soc. S. Aust., 49:273 (1925); Fl. S. Aust., 371, t. 163 (1926).

New South Wales—along River Darling, between Wilcannia and Pooncarra, May 1939, *Col. Builer*. I don't know whether this plant has been previously recorded for New South Wales; it is not mentioned in Moore & Betche's Fl. N.S.W. (1893), or in Maiden & Betche's Cens. N.S.W. Plants (1916).

Apparently rare, though widely distributed, it has now been found at Charlotte Waters, C. Aust., *E. Giles* (1874); Eucla, W. Aust., *J. D. Bett* (1889); Mount Lyndhurst Run, S. Aust., *M. Koch* (1898), and this year on the Darling.

A specimen from the Darling was sent to the Kew Herbarium, where it was named as above. The Director (Sir Arthur Hill) adds: "We have not made a detailed investigation of this species, but *Gilesia* is probably generically distinct from the African *Hermannia*."

The principal distinction appears to be that *Gilesia* has free, narrow-linear filaments, while *Hermannia* has broad flat filaments, united at least towards the base and usually much dilated in some portion of their length. The seed of *Hermannia* is described as having the radicle next the hilum; in *Gilesia biniflora* the hilum lies midway between the radicle and the chalazal end of the seed. The seeds are pendulous and the radicle turned inwards towards the placenta. (fig. 2.)

Helichrysum decurrens F. v. M. Fragm. 8:44 (1873) = *H. retusum* Sond. et F. v. M. Fragm. 8:46 (1873) non Spreng. Syst. 3:484 (1826); *Ozothamnus retusus* Sond. et F. v. M. in Linnaea 25:510 (1852); *H. adnatum*, Benth. Fl. Aust. 3:628 (1866) pro parte.

South Australia—Harrogate; Strathalbyn; Nuriootpa; Goolwa; Pinnaroo; Lameroo; Karoonda; Wynarka; Murray Bridge; Kangaroo Island; Gladstone; Stansbury, Y.P.; Port Lincoln, Yeelanna, E.P. The specimens from Kangaroo Island have broader leaves, showing more of the white undersurface.—Also in Victoria and New South Wales.

My reasons for treating *H. decurrens* and *H. retusum* as one species, and *H. adnatum* Benth. as distinct, were given in Trans. Roy. Soc. S. Aust., 40:74 (1916) but the name then adopted and in the Fl. S. Aust. was *H. retusum*. Under the International Rules of 1935 *H. retusum* Sond. et F. v. M. is now illegitimate, being a later homonym of *H. retusum* Spreng.

Var. **scabrum** (Benth.) nov. comb. Varies in the longer leaves (5-30 mm. long and barely 1 mm. broad), very scabrous with stiff short hairs on the upper surface, the upper leaves erect or erect-spreading.—*Ozothamnus scaber* F. v. M. in Linnaea, 25:407 (1852); *H. adnatum* var. *scabrum* Benth. Fl. Aust., 3:629 (1866).

Flinders Range. The type of *O. scaber* was collected by Mueller in October 1851, at Crystal Brook, Cudnaka and Ultonulta. The last two names are not known in the Land Office today, but probably Cudnaka is an early form of Kanyaka. On other labels signed by Mueller it is quoted as near Arkaba. Exactly similar specimens have been collected in recent years on the hills near Hawker and Quorn. It has sometimes been confused with *Cassinia aculeata*.

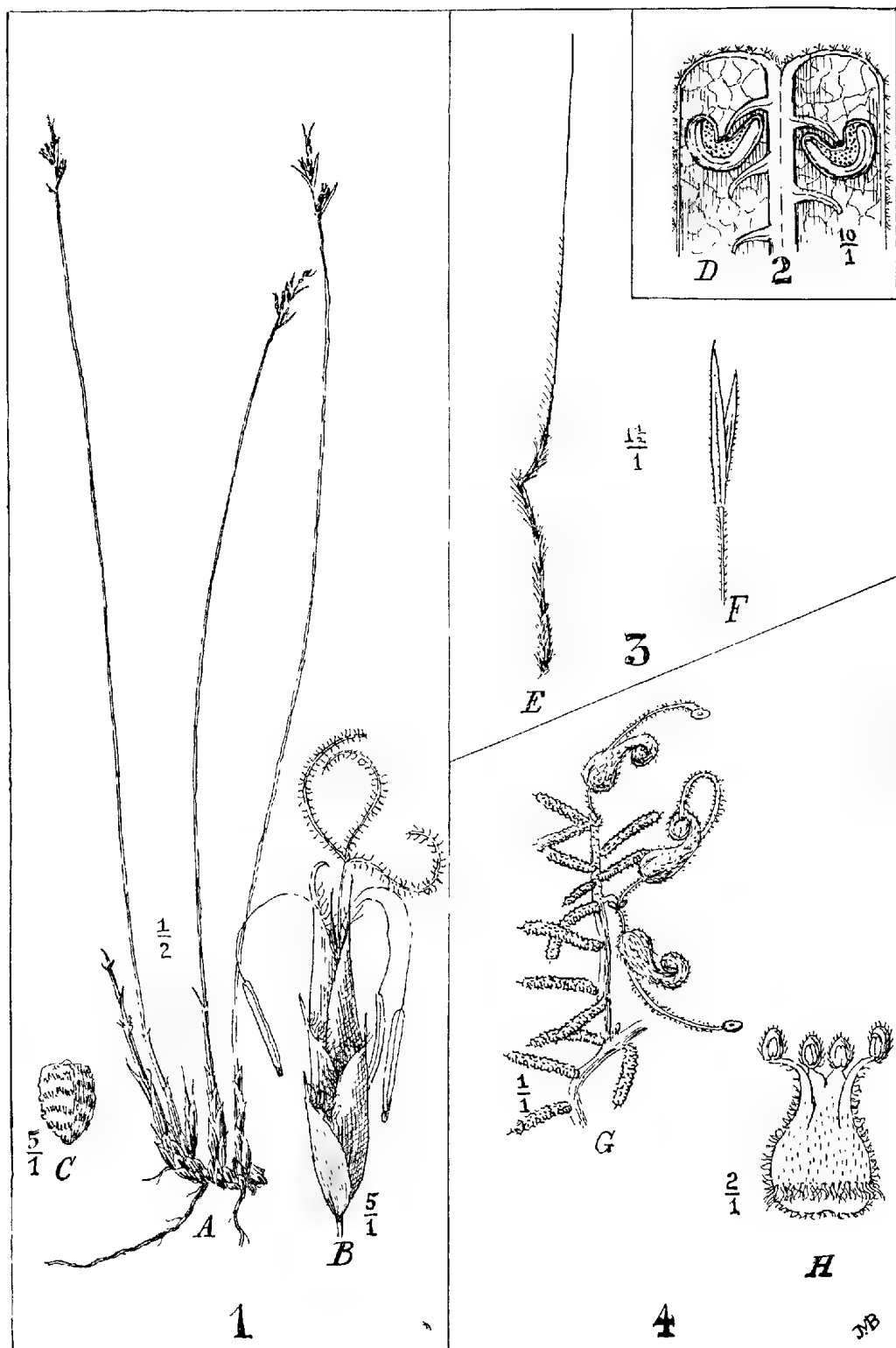
EXPLANATION OF FIGS. 1-4

Fig. 1 *Schoenus racemosus*—A, the plant; B, spikelet; C, nut.

Fig. 2 *Gilesia biniflora*—D, upper part of one valve of the capsule with two seeds in position and bisected longitudinally.

Fig. 3 *Stipa hemipogon*—E, awn; F, outer glumes.

Fig. 4—*Grevillea muricata*—G, branch; H, perianth spread open.



1, *Schoenus racemosus*; 2, *Gilesia biniflora*; 3, *Stipa hemipogon*; 4, *Grevillea muricata*

THE AUSTRALIAN ABORIGINAL SKULL: ITS NON-METRICAL MORPHOLOGICAL CHARACTERS

By FRANK J. FENNER, M.B., B.S.
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Summary

In 1931 Wood Jones (31) pointed out the importance of non-metrical morphological features in the study of the racial characters of the human skull. He drew up a scheme for the description of these features, and in later papers (32) (33) (34) (37) analysed several series of skulls according to this scheme. Krogman (16), in 1932, described the Australian aboriginal skulls housed in the Royal College of Surgeons Museum, England, following Wood Jones's arrangement. As Krogman noted, his series was too small to determine whether any geographical variation in these features occurred. For this reason, and because Krogman's study did not appear adequate in certain respects, this work, which comprises the detailed examination of 1,182 adult Australian aboriginal crania, was undertaken. The geographical distribution of these skulls is as shown below:

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[Read 14 September 1939]

PLATES X AND XI

In 1931 Wood Jones (31) pointed out the importance of non-metrical morphological features in the study of the racial characters of the human skull. He drew up a scheme for the description of these features, and in later papers (32) (33) (34) (37) analysed several series of skulls according to this scheme. Krogman (16), in 1932, described the Australian aboriginal skulls housed in the Royal College of Surgeons Museum, England, following Wood Jones's arrangement. As Krogman noted, his series was too small to determine whether any geographical variation in these features occurred. For this reason, and because Krogman's study did not appear adequate in certain respects, this work, which comprises the detailed examination of 1,182 adult Australian aboriginal crania, was undertaken. The geographical distribution of these skulls is as shown below:

State					Male	Female
South Australia	-	-	-	-	291	271
Victoria	-	-	-	-	103	90
New South Wales	-	-	-	-	106	82
Northern Territory	-	-	-	-	94	66
Queensland	-	-	-	-	59	47
Western Australia	-	-	-	-	19	8

Pathological skulls, skulls of children, and specimens from unknown localities were excluded from the series. The skulls examined are housed in the following institutions: South Australian Museum, Adelaide; Museums of the Department of Anatomy, University of Adelaide; National Museum, Melbourne; Museum of the Department of Anatomy, University of Melbourne; Australian Museum, Sydney; Australian Institute of Anatomy, Canberra.

I owe sincere thanks to Professor F. Wood Jones, late of the University of Melbourne; Dr. C. S. Mead, late of the University of Adelaide; Mr. D. J. Mahony, Director of the National Museum, Melbourne; Dr. C. Anderson, Director of the Australian Museum, Sydney; the late Sir Colin Mackenzie, who was Director of the Australian Institute of Anatomy, Canberra; and the Board of Governors of the South Australian Museum, Adelaide, for their permission to examine the skulls in their care and for the ready assistance they kindly offered.

The expenses incurred in this investigation were defrayed by grants by the Council of the University of Adelaide from the David Murray Scholarship Funds.

It was hoped, in commencing this work, that variations in the cranial characters in the different geographical regions of Australia could be compared. It soon became apparent, however, that this would be difficult. The only easily decided geographical division, *i.e.*, the division into States, is a political and in no sense a biological one. The mass of detail involved in such a comparison would also be unwieldy.

The impression gained from the examination of this large series of skulls is that there are three geographical groups of skull types: (1) the southern group (type A), comprising those from Southern and South-western Queensland, New South Wales, Victoria and South Australia; (2) the Northern Territory group (type B); and (3) the Queensland group (type C). Following the advice of Professor Wood Jones, I have treated the whole series of skulls as a unit—the Australian skull, commenting on local variations where these exist.

The scheme of examination followed is that elaborated by Wood Jones, with a few additions. The considerable sexual difference in the Australian aborigines makes the sexing of most of the skulls fairly easy. Where other parts of the skeleton were present, the sex of the skull was checked by their examination. Hrdlicka (12) and Klaatsch (15) had previously sexed many of the skulls of this series. I sexed these specimens independently, and in the great majority of cases my determinations agreed with those of Klaatsch and Hrdlicka.

Each skull was then examined in detail, and the results of the examination recorded on cards, which were printed by and are preserved in the South Australian Museum. The results were correlated and the occurrence of the various features described are presented below as percentages. Some of the skulls examined were damaged and could not be examined completely—the number of skulls on which any observation was made has therefore been indicated.

(1) *Cranial Form* (Number of skulls, 669 ♂, 506 ♀).

The dolichocephaly of the Australian skull is well known. Following Sergi's classification of cranial form for the *norma verticalis* we get the following figures:

TABLE I

Cranial form	Complete Series	
	♂	♀
Long ovoid - - - -	61%	61%
Long brisoid - - - -	24%	26%
Long ellipsoid - - - -	10%	3%
Rather short, wide ovoid - -	3%	5%
Pentagonal ovoid - - -	2%	5%

The dominant form is a long ovoid with a narrow bifrontal and moderate biparietal diameter. The temporal fossae are poorly filled; in those forms classed as brisoid the line of the temporal fossa was distinctly concave. The long

ellipsoid type corresponds to a long ovoid in which the parietal bosses and the biparietal diameter are reduced. The most strongly dolichocephalic skulls generally fall into this class, which is predominantly a male type. The other two types correspond with the mesocephalic skulls (see Hrdlicka's (12) figures), the rather wide ovoid presenting a general broadening of the skull in both parietal and frontal areas, and the pentagonal ovoid type having a greatly expanded biparietal breadth and a narrow bifrontal diameter. These broader skulls were twice as common in females as in males, and generally the female skulls are less dolichocephalic than the male. Some of the pentagonal ovoid class bore a remarkable resemblance in general cranial form to the Tasmanian skulls.

Of the local groups many of the Queensland skulls were shorter and their temporal fossae better filled than in the typical southern skull. Hrdlicka (12), by his measurements, found that "Both the absolute height and the (mean height) index are lowest or next to lowest in South Australia, where the cephalic index is also low; and both are high in Queensland where the cephalic index is also higher." From *norma verticalis* most skulls were strongly phaeozygous, only 1.6% of male and 3.1% of female skulls approaching a cryptozygous condition. Amongst the Queensland skulls, however, 11.8% of the male and 14.9% of the female skulls approached cryptozygy. This is an indication of the better filled temporal fossae and shorter rounder skulls occurring in North Queensland.

As would be expected from the strong masticatory apparatus of the Australian aborigine, the temporal lines were generally strongly developed and extended far up on the vault of the skull. Below the inferior temporal line became continuous with a well-developed supramastoid crest on the squamous part of the temporal bone, thus limiting the planum temporale sharply behind and below. This supramastoid crest could always be detected, although in many female skulls it was only slightly developed. The degree of development of temporal lines and supramastoid crest is summarized in the following table:

TABLE II

Development	Parietal Tuberosity		Temporal Line		Supramastoid Crest		Frontal Eminences	
	♂	♀	♂	♀	♂	♀	♂	♀
Absent - - -	2%	1%	—	—	—	—	10%	5%
Slight - - -	23%	14%	—	—	3%	10%	48%	25%
Small - - -	48%	47%	—	—	60%	72%	39%	63%
Moderate - -	25%	31%	1%	12%	36%	18%	3%	7%
Great - - -	2%	7%	68%	85%	1%	—	—	—
Very great - -	—	—	31%	3%	—	—	—	—

Parietal tuberosities could be distinguished on the majority of skulls. They were rarely very prominent (Table II) and in only a small number of skulls was that "full-blown" appearance in the parietal region, which characterises the Tasmanian cranium, in evidence. There were no local variations beyond a some-

what greater development of the parietal bosses in male Queensland and female Victorian skulls.

Small frontal eminences (tuber frontalia) can be distinguished on most Australian skulls, often better by touch than by sight. Sometimes they show up clearly on a flat "penthouse" forehead. Their development is summarized in Table II; there were no local variations of any significance.

The paramedian flattening of the Australian skull on either side of an elevated sagittal ridge of the parietal and often the frontal bones has been mentioned by most observers. Klaatsch (15), working on Roth's series of Queensland crania, discussed in some detail the form that this ridge may take in the Australian skull. He suggested that there was a relationship between this sagittal frontal ridge (the torus frontalis medianus) and the bregmatic eminence and ridge of *Pithecanthropus*. There was considerable variation in this feature in the present series of skulls. It was sometimes completely absent, this occurring both in some of the female skulls with rounded well-filled foreheads, and in occasional males with very receding flat foreheads. In its extreme development it passes up from a strong glabella as a prominent rounded ridge on the frontal bone, obliterating the supraglabellar fossa (which generally lies just above glabella). It may end at the bregma or may pass back as a prominent ridge on the anterior part of the parietal bones. In the latter case, the paramedian areas of the parietal bones were usually flat and ill-filled, especially at the anterior end, this form corresponding to the bregmatic eminence of Klaatsch. Sometimes this bregmatic eminence took the form of a flattened elevated shield at the bregma. All degrees of development from complete absence to the condition described above are encountered.

A ridge occupying only the upper two-thirds of the frontal bone was not uncommon. Juvenile skulls often showed a prominent development of the torus frontalis medianus, and it is a very prominent feature of scaphocephalic skulls. (10.) Table III shows the degree of development of the median frontal ridge in this series.

TABLE III

Median frontal ridge Development						Complete Series	
						♂	♀
Absent	-	-	-	-	-	25%	40%
Slight	-	-	-	-	-	21%	27%
Small	-	-	-	-	-	38%	28%
Moderate	-	-	-	-	-	14%	4%
Great	-	-	-	-	-	2%	0.6%

The ridge continues back on to the anterior part of the parietal bones in 17% of male and 5% of female skulls (Table IV).

In 1% of males and 2% of the female skulls there was a ridging of the anterior part of the parietal bones in the midline, without a ridge of the frontal bone.

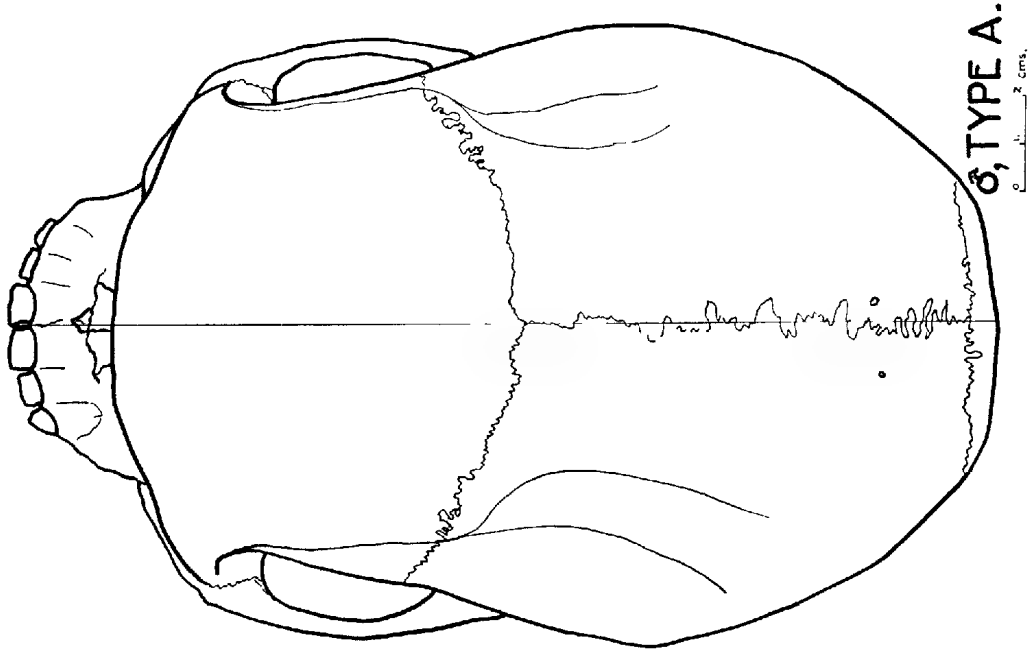


Fig. 1
Norma verticalis of male South Australian skull
(A 20587, S.A.M., Adelaide, from Fulham, S.A.)

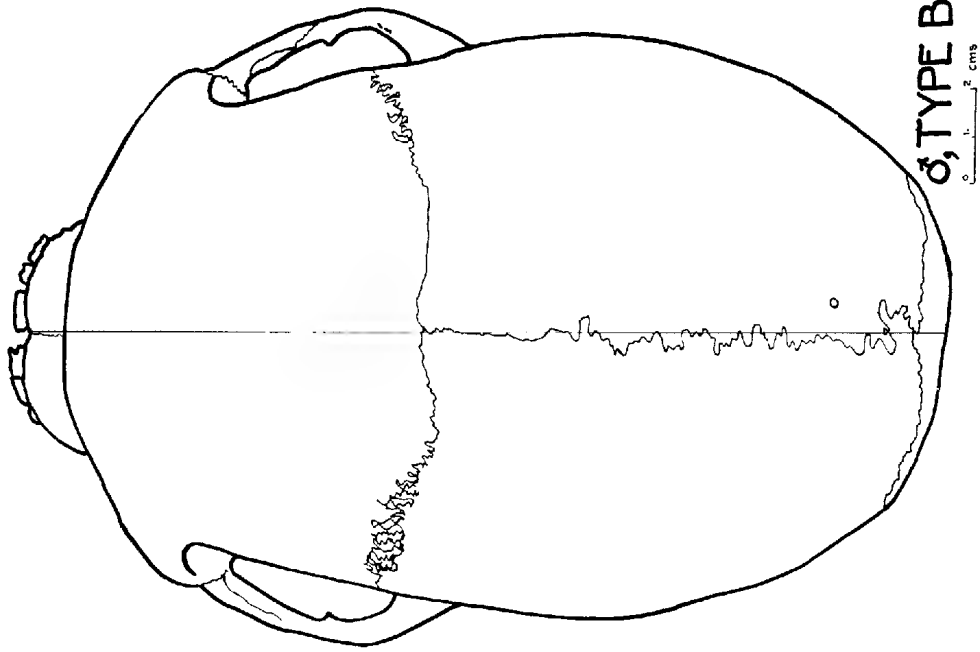


Fig. 2
Norma verticalis of male Northern Territory skull
(A 11434, S.A.M., Adelaide, from Melville Island, N.T.)

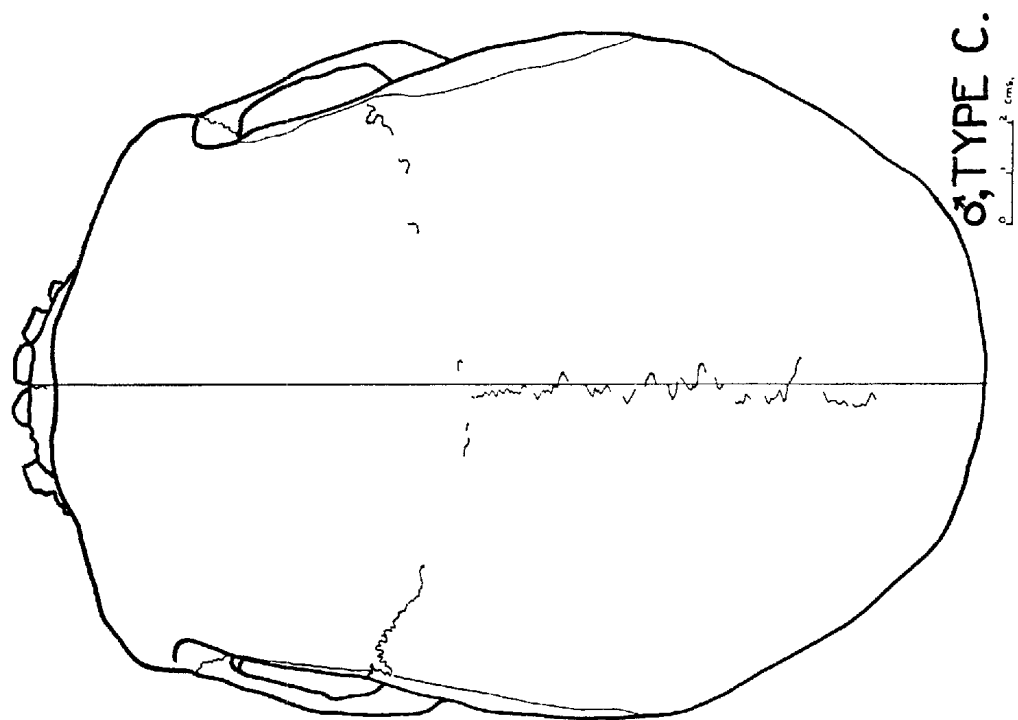


Fig. 3
Norma verticalis of male Queensland skull
(E 15199, Aust. Mus., Sydney, from Mt. Morgan, Q.)

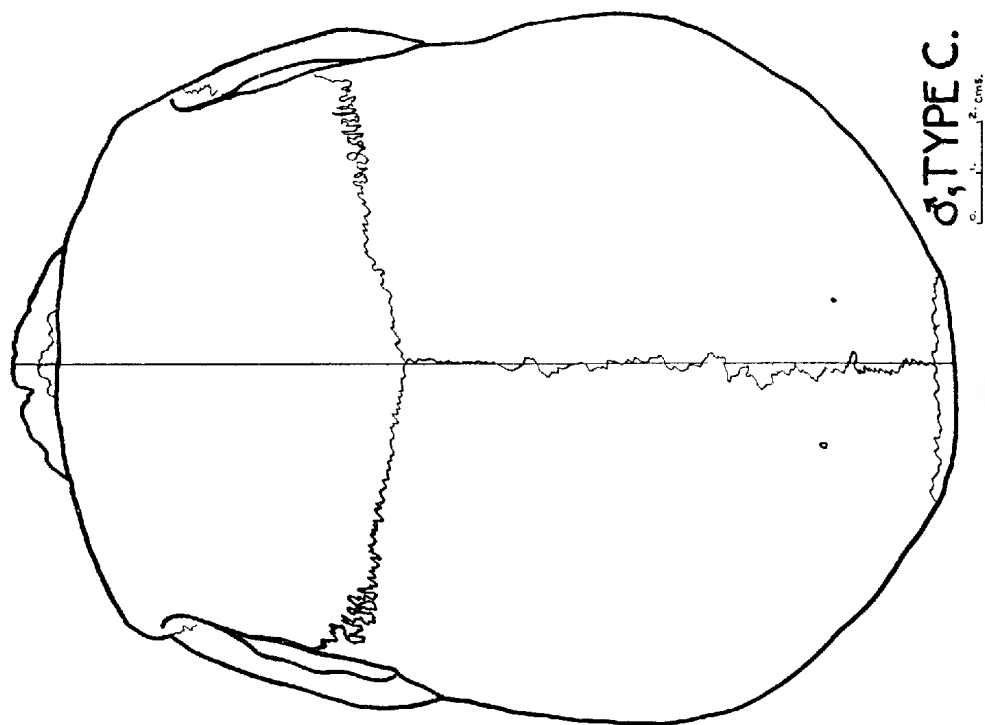


Fig. 4
Norma verticalis of male Queensland skull
(1233, Aust. Mus., Sydney, from Cape York, Q.)

TABLE IV

Parietal prolongation						Complete Series	
Development						♂	♀
Absent	-	-	-	-	-	83%	95%
Small	-	-	-	-	-	12%	4%
Moderate	-	-	-	-	-	5%	1%

In two male skulls a prominent frontal ridge was divided by a shallow median groove. In three male skulls the whole of the sagittal region of the frontal and parietal bones was raised into a ridge, and in one male skull a median crest was present only in the neighbourhood of the obelion.

The sagittal suture sometimes lies in the bottom of a depression and there are two factors involved in the production of this phenomenon. Firstly, the anterior part of the sagittal suture, the pars bregmatica, may be situated in the bottom of a groove. In these cases there was generally associated with the groove a continuation of the median frontal ridge into the parietals.

Secondly, the pars obelica of the sagittal suture is occasionally situated in the bottom of a rather wide excavation. This condition, originally termed the depressio prelambdoidea by Barkow,⁽¹⁾ extends sometimes into the pars lambdoidea of the sagittal suture. It is more common in female than in male skulls and is not accompanied by an elevation of the adjacent parts of the parietal bones. Shore (23) has recently discussed the excavation of the sagittal suture in detail. He has named it the interparietal groove, and that term will be used here. Turner (28) and Wunderly (39) have commented on the frequent and pronounced development of this interparietal groove in Tasmanian skulls. Occasionally the whole length of the sagittal suture lay in the bottom of a slight groove, and occasionally the groove was confined to the pars lambdoidea. The occurrence of this feature is summed up in Table V.

TABLE V

Interparietal groove			Groove confined to						
Development			Pars bregmatica		Pars obelica		Pars lambdoidea		
			♂	♀	♂	♀	♂	♀	
Slight	-	-	5%	3%	0.7%	2.2%	—	—	
Small	-	-	19%	6%	4.5%	9.7%	1.2%	1.0%	
Moderate	-	-	3%	1%	0.6%	3.1%	—	—	

The whole sagittal suture lay in a groove in 3.4% of male and 1.2% of female skulls. Grooving of the pars obelica was somewhat less common in the Queensland skulls, a fact possibly related to the steeper occipital planing in these specimens.

Norma lateralis—It is probably from this aspect that the regional differences in the shape of the cranium are best seen. The prognathism and depressed nasion

⁽¹⁾ Quoted by Klaatsch (15), p. 131

contribute largely to the "typically Australian" appearance of the skull from norma lateralis. Campbell (5) has investigated the prognathism of many of the skulls of this series, and further description seems unnecessary. The depressed nasion and the form of the glabella will be treated in detail later (see under 11, *The Form of the Orbit*).

The diophterographic tracings of Berry and Robertson (1) will have familiarized workers with the typical normae of the Australian skull. A consideration of the outline of the cranial vault as seen in the lateral norma resolves itself into a consideration of three parts: (1) the forehead from glabella to bregma, (2) the superior parietal portion from bregma to a point on the parietal bone about one centimetre anterior to obelion, and (3) a posterior parietal and superior occipital part between this point and inion.

In most cases the forehead recedes in a striking manner, although rounded high foreheads are met with, particularly in female skulls. Woollard (36) notes that in the aboriginal brain "the frontal pole slopes sharply backwards, not having the fulness which is present in the European brain." There are distinct local variations in the slope of the forehead, as can be seen from a consideration of Table VI.

TABLE VI

	Complete Series		Northern Territory Only		Queensland Only	
	♂	♀	♂	♀	♂	♀
Recession of forehead						
Recedes strongly -	45%	28%	53%	33%	28%	13%
.. moderately	48%	57%	39%	57%	48%	50%
.. slightly -	7%	15%	8%	10%	24%	37%

The male Northern Territory skulls showed the greatest degree of recession, many of the strongly masculine specimens having remarkably low flat foreheads. Amongst the Queensland aborigines, on the other hand, the forehead was much higher and more rounded, and the strongly receding, flat, "penthouse" type of forehead was rarely met with.

Between the bregma and a point generally situated a centimetre or so anterior to the obelion the contour from norma lateralis was almost flat or slightly convex upwards. At this posterior point the contour line took a fairly abrupt turn down, the outline of this posterior part of the cranium is very typical of the skulls from different localities. The typical southern Australian form is a flat, gently sloping, line as far as lambda, and below this point the occipital bone may project back, or may curve forwards slightly to the inion. In the Queensland and Northern Territory skulls the posterior parietal region falls off much more abruptly; it is generally flat but at times is somewhat rounded.

Two special types of contour were common amongst the Northern Territory specimens, especially the male skulls. Firstly, a type in which the forehead was flat and low and seemed to pass back to just behind the bregma. There was no distinct superior parietal portion as in the southern Australian skulls—the outline of the

TABLE VII
Contour of posterior parietal region and occipital plane
of squama occipitalis.

	Complete Series		Northern Territory Only		Queensland Only	
	♂	♀	♂	♀	♂	♀
Recedes gently:						
flat - - -	74%	78%	46%	56%	52%	51%
rounded - - -	12%	7%	19%	12%	9%	4%
Recedes abruptly:						
flat - - -	12%	13%	29%	24%	36%	45%
rounded - - -	2%	2%	6%	8%	3%	—

parietal region fell away fairly abruptly from a point just behind the bregma. This was found in 24% of the Northern Territory male and 17% of the female skulls. Secondly, a variety in which the line from glabella toinion was an even curve, with no angulation or division apparent between forehead and superior parietal region or between superior and posterior parietal regions, nor did the occipital plane of the squama occipitalis bulge backwards. This type occurred in all groups, but more frequently in Northern Territory male skulls than in the others (5% of all male skulls, 15% of male Northern Territory skulls). It did not occur to a greatly increased extent in the Northern Territory female skulls (4% of all female and 6% of Northern Territory female skulls).

It was noted in discussing the excavation of the posterior part of the sagittal suture (the interparietal groove of Shore (23)) that this condition had been termed the "depressio prelamboidea." As Klaatsch (15) points out, the use of this term has been extended by Le Double and Broesicke to denote the transversely directed depression of the posterior part of the parietalia. This latter condition has been noted in a large number of aboriginal skulls, but here it seems to be due rather to a projection backwards of the whole of the occipital plane of the squama occipitalis than to a depression of the posterior part of the parietal bone. The appearance of the inside of a skull showing a well-developed occipital bulge supports this interpretation. There are two deep symmetrical excavations between the lambdoid suture and the transverse sinus. Endocranial casts and aboriginal brains also show that the occipital region of the brain often bulges strongly backwards. Woollard (36) has noted that "the occipital pole which

TABLE VIII

Occipital bulge Development	Complete Series		Northern Territory Only		Queensland Only	
	♂	♀	♂	♀	♂	♀
Absent - - -	26%	27%	39%	47%	45%	41%
Slight - - -	15%	18%	20%	28%	13%	20%
Small - - -	42%	42%	27%	23%	36%	35%
Moderate - - -	15%	13%	10%	2%	6%	4%
Great - - -	2%	0.6%	4%	—	—	—

looks like a slender projection in the baby, still retains its protuberant aspect in the mother, though becoming more of a rectangular block." Table VIII shows the varying development of this occipital bulge.

The Northern Territory and Queensland skulls show a lesser development of this occipital bulge than the southern ones. This may be correlated with the steeper occipital planing of the crania from these regions.

Norma occipitalis—From *norma occipitalis* the Australian skull typically has parallel sides and a gabled roof.

TABLE IX

<i>Norma occipitalis</i>				Complete Series	
				♂	♀
Gabled roof:					
with parallel sides	-	-	-	59%	55%
with converging sides	-	-	-	27%	17%
with diverging sides	-	-	-	7%	13%
Rounded roof:					
with parallel sides	-	-	-	4%	9%
with converging sides	-	-	-	2%	1%
with diverging sides	-	-	-	0·3%	2%
side and roof rounded	-	-	-	0·7%	2%

The area between the sagittal suture and the parietal bosses may be flat or even concave. When the median frontal ridge continues back on to the anterior part of the parietals this gabled appearance is accentuated. This flatness of the parietals, the receding forehead and beetling brows give to the Australian cranium that so-called brutal aspect on which so many observers have commented. These skulls have been described in Table IX as having a "gabled roof." In other specimens these parts of the parietals are more rounded, so that from *norma occipitalis* the roof looks like the arc of a circle; these have been described in the table as "rounded roof." The lateral walls are generally straight or slightly rounded. Depending on the degree of development of the parietal bosses the lateral walls may be parallel, converging or diverging upwards. The diverging type is characteristic of juvenile and some female aboriginal skulls.

In some male crania the parietal tuberosities are small and the lateral walls, from *norma occipitalis*, converge somewhat above. As Klaatsch has noted, this temporal area is sometimes concave, limited below by the strongly developed mastoid crest. In these cases the greatest skull breadth usually lies on the temporal squama just above the supramastoid crest.

In the majority of Australian skulls a transverse occipital torus is present between the superior and supreme nuchal lines. Klaatsch has analysed this condition in some detail in the Queensland skulls of the Roth collection. It is found in all degrees, from a slight rounded elevation between the superior and supreme nuchal lines, to a remarkably prominent torus. The torus is sometimes divided into two prominent lateral parts by a median depression. In a few instances there is a slight development of the external occipital protuberance.

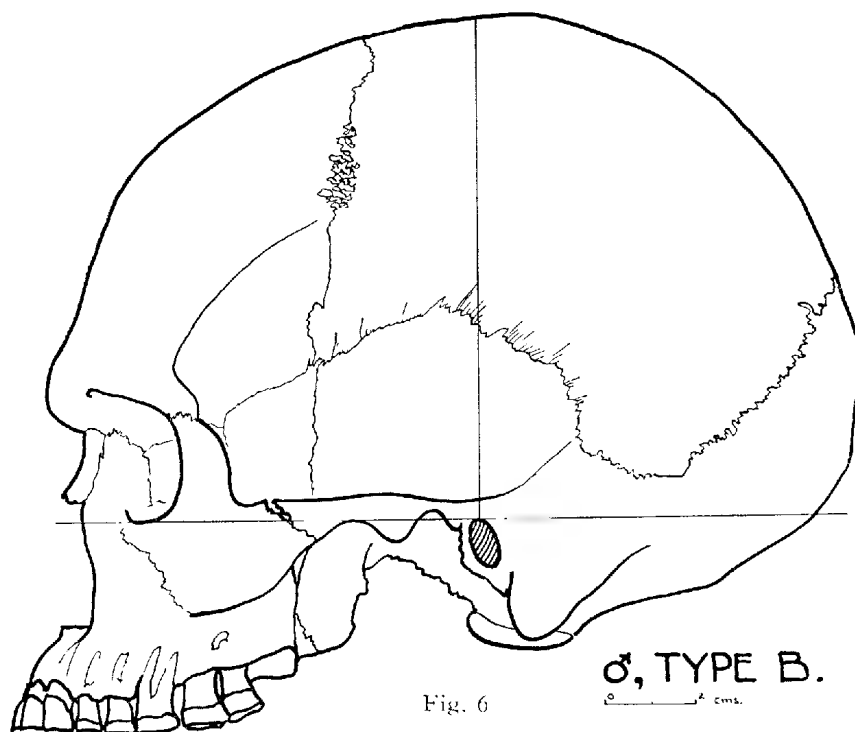
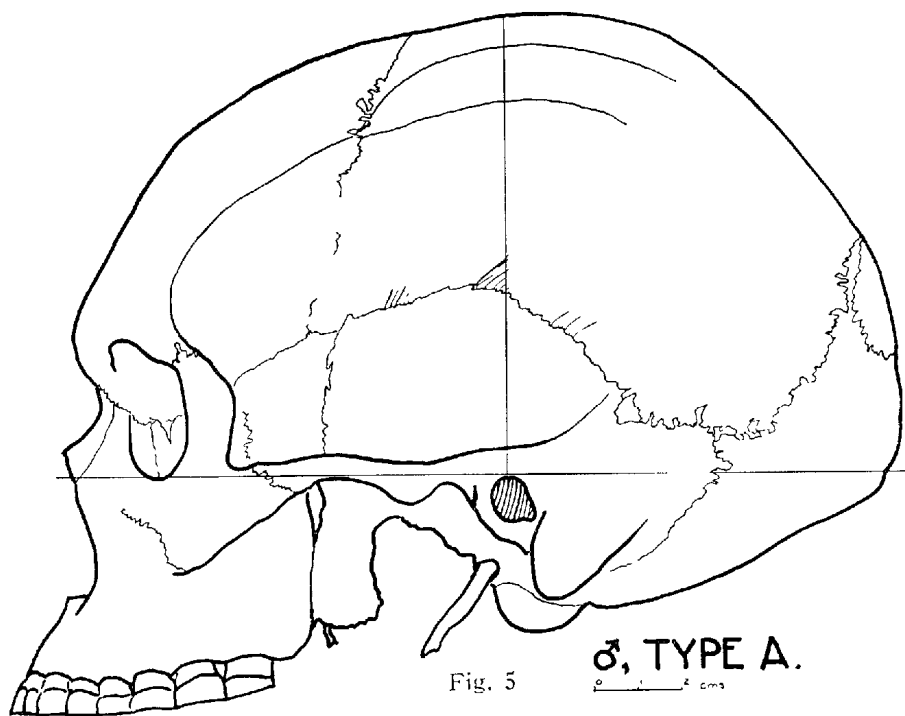


Fig. 5—Norma lateralis of male South Australian skull (A 20587, S.A.M., Adelaide, from Fulham, S.A.)

Fig. 6—Norma lateralis of male Northern Territory skull (A 11434, S.A.M., Adelaide, from Melville Island, N.T.)

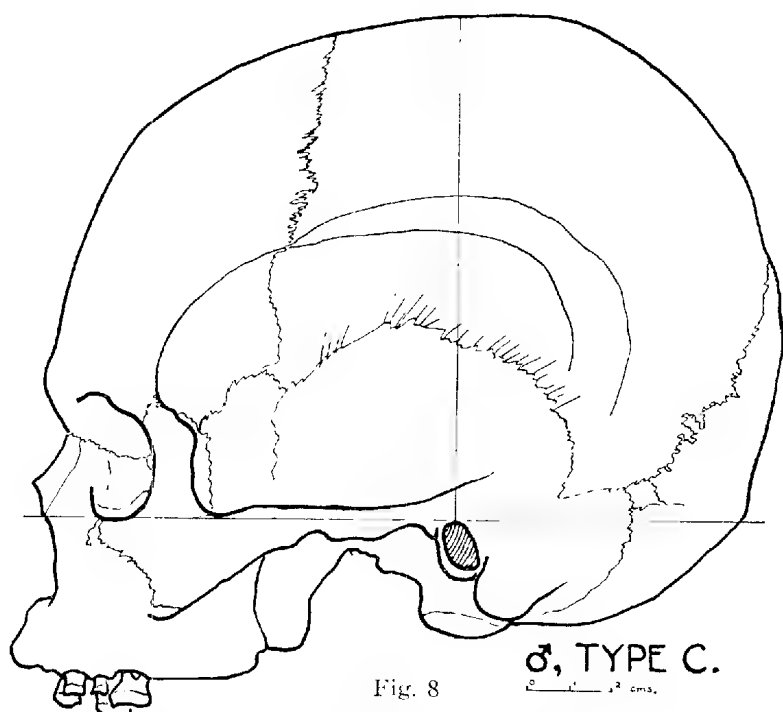
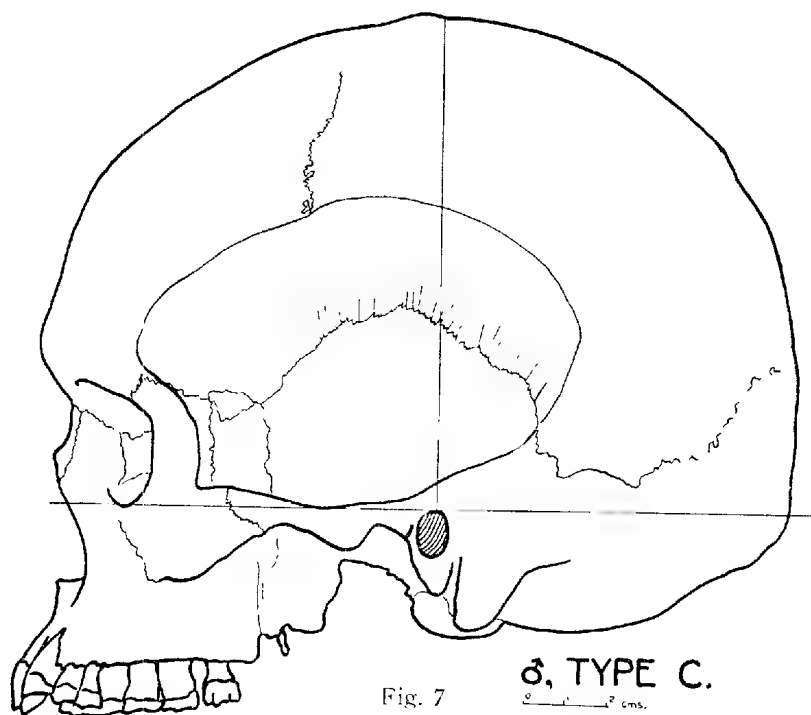


Fig. 7—Norma lateralis of male Queensland skull (E 15199, Aust. Mus., Sydney, from Mt. Morgan, Q.)

Fig. 8—Norma lateralis of male Queensland skull (1233, Aust. Mus., Sydney, from Cape York, Q.). The influence of Melanesian contamination is obvious from the proportions of this specimen.

TABLE X

Transverse occipital torus:							Complete Series	
							♂	♀
Absent	-	-	-	-	-	-	7%	18%
Slight	-	-	-	-	-	-	16%	28%
Small	-	-	-	-	-	-	47%	41%
Moderate	-	-	-	-	-	-	25%	12%
Great	-	-	-	-	-	-	5%	0.6%
Very great	-	-	-	-	-	-	2 skulls	
External occipital protuberance:								
Absent	-	-	-	-	-	-	95%	99%
Small	-	-	-	-	-	-	3%	1.4%
Moderate	-	-	-	-	-	-	2%	—

CRANIAL FORM—SUMMARY

Summarizing, we may say that the Australian skull is long, low and narrow, with deep temporal fossae, receding forehead and a gently sloping, flattened, posterior parietal region. The development of a sagittal ridge of the frontal bone and the flatness of the parietal bones between the tuberosities and the

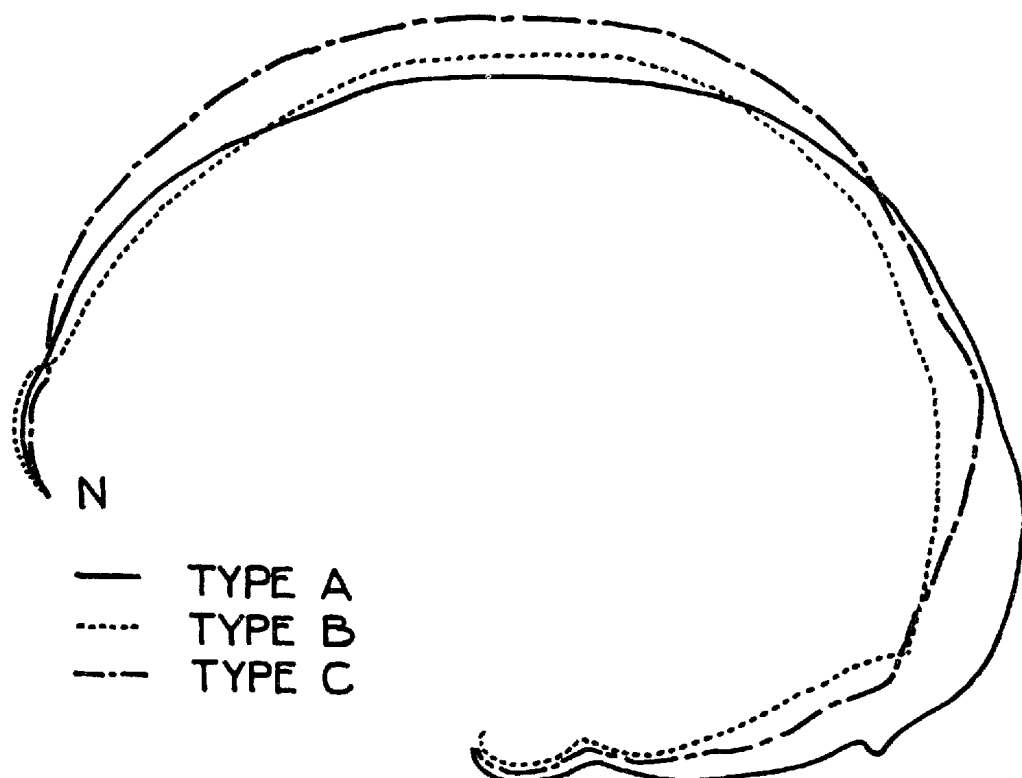


Fig. 9

Dipterographic tracings from norma lateralis of the outlines of typical male skulls from South Australia, Northern Territory, and Queensland. The differences in contour described in the text are evident.

sagittal suture contribute to the "ill-filled" appearance of the skull. The occipital and nuchal planes of the squama occipitalis generally meet at a rather sharp angle, and their junction is marked by the development of a prominent transverse occipital torus. The female skull is somewhat shorter, higher, and more rounded than the male.

Regional variations are found in the Northern Territory and Queensland crania, the former usually having low receding foreheads and a steeply planed posterior parietal and occipital region, and the latter having higher foreheads, fuller temporal fossae, shorter, higher skulls and a steeply planed posterior parietal and occipital region. The skulls from the Northern Territory area are on the whole narrower and smaller than the others.

Hrdlicka (12) has measured an extensive series of Australian skulls. It may be useful to quote some of his conclusions about regional variations as determined metrically. "Both the absolute height and the (mean height) index are lowest or next to lowest in South Australia, where the cephalic index is also low; and both are high in Queensland where the cephalic index is also higher . . . in north-western and northern Australia where the cephalic index is decidedly low, the height index is near or at the maximum. In size the skull is smallest in the Northern Territory and north-western Australia, largest in Victoria . . . The facial angle is lowest (greatest prognathism) in south and west Australia, highest in Queensland . . . the palate is relatively longest (or narrowest) in central and south Australia, relatively shortest (or broadest) in Queensland, and especially in north-west Australia⁽²⁾ . . . Admixture (Papuan) and local variations are doubtless both involved in the observed differences of characters. But these differences are so appreciable that anthropology will hardly be justified henceforth to refer merely to 'the Australian'."

(2) *Cranial Asymmetry* (Number of skulls, 662 ♂, 501 ♀).

Estimated from norma verticalis there was quite a high degree of symmetry.

TABLE XI							
Cranial asymmetry				Complete Series			
From norma verticalis				From all aspects			
				♂	♀	♂	♀
Symmetrical	-	-	-	66%	61%	43%	39%
Normal asymmetry	-	-	-	26%	33%	45%	52%
Reversed asymmetry	-	-	-	8%	6%	12%	9%

By rotating the skulls which appeared symmetrical from norma verticalis about a transverse axis through the auditory meatus, it was found that the left occipital prominence (normal asymmetry) was present in 29% of these male and 31% of these female skulls. Right occipital prominence (reversed asymmetry) was present in 5% of both sexes. The complete figures are given in Table XI.

⁽²⁾ In this sentence Hrdlicka's comments (not quoted here) referring to the facial angle are erroneous (according to his tables of figures)

(3) *Sutures* (Number of skulls, 669 ♂, 507 ♀).

In all Australian skulls the sutures are simple.

Coronal suture—The pars bregmatica of the coronal suture was noted as simple or very simple. The pars complicata was noted as simple in 67% of the male and 59% of the female skulls, and complicated in 33% of the male and 41% of the female skulls. The pars temporalis was linear in 80% and simple in 20% of both sexes.

Sagittal suture—In 92% of the male and 94% of the female skulls the sagittal suture was simple, in the remainder complicated. The pars obelica of the sagittal suture was either linear or simple in type.

Lambdoid suture. The lambdoid suture was simple in 56% and complicated in 44% of both sexes. The pars asterica was usually linear or very simple, the pars media the most complicated section and the pars lambdoidea simple or complicated.

Traces of the transverse occipital suture were present bilaterally in 19 males and five female skulls. A complete transverse occipital suture was present in three male and three female skulls.

A metopic suture was present in four male and five female skulls and traces of the frontal suture persisted in 11 male and 18 female skulls.

Augier (Poirier, Charp and Nicolas (22)), in discussing the synostosis of the bones of the vault, suggests that Todd and Lyon (26) have insufficient basis for contradicting Gratiolet's law, that synostosis occurs earlier in inferior human races than in civilized ones. In order to obtain data bearing on this question, and also because the order of sutural fusion seemed to differ somewhat from Todd and Lyon's scheme, the degree and order of sutural fusion was noted. The less reliable synostosis of the outer table was all that could be determined, as very few skulls had been opened.

Complete fusion of the coronal, sagittal, and lambdoid sutures was noted in 21 male and 17 female skulls, and in 46 male and 22 female skulls the sagittal, coronal and pars lambdoidea of the lambdoid sutures were completely fused.

Considering only those skulls in which fusion had commenced but was not complete, it was most advanced in the sagittal suture in 73% of the male and 48% of the female skulls. In 26% of the male and 52% of the female skulls fusion had proceeded furthest in the coronal suture, and in five male skulls (1%) the lambdoid suture was more completely fused than either the sagittal or coronal sutures. Fusion was more advanced in the lambdoid than in the coronal suture in 14% of the male and 2% of the female skulls.

In the coronal suture fusion had proceeded furthest in the pars temporalis in 83%, and in the pars bregmatica in only 7%. In 8% the pars bregmatica and the pars temporalis were synostosed to about the same degree, and in 1% the pars complicata showed the most advanced synostosis. These figures were approximately the same in the two sexes.

Fusion usually started in the pars obelica of the sagittal suture and extended from there anteriorly and posteriorly. The pars bregmatica was generally the last

to fuse, in 33% of the skulls in which the sagittal suture was partly fused it is the only region in which there was no complete synostosis. In a few skulls, 7% of the male and 18% of the female specimens with synostosis of the sagittal suture, fusion was most advanced in the pars bregmatica. It was noticed that in a number of these the pars bregmatica of the coronal suture had also fused earlier than the other parts of that suture, *i.e.*, fusion seemed to spread from bregma in all directions. In the lambdoid suture synostosis almost invariably commenced in the pars lambdoidea. Several skulls showing anomalies of sutural synostosis were noted, but a detailed description of these is not warranted here.

Comparing these figures with those of Todd and Lyon, it appears (at least from the exocranial aspect) that fusion is most advanced in the coronal and not the sagittal suture in quite a high proportion of cases. Todd and Lyon considered that the synostosis of the coronal suture usually began in the superior or bregmatic portion; in Australians it almost always begins in the inferior portion or pars temporalis.

Owing to the impossibility of determining the ages of any of the skulls a rigid comparison of sutural fusion in the Australian and other races is impossible. All we may say is that the order of fusion appears to differ somewhat from that in Europeans, and that of the three great sutures of the cranial vault, fusion was nearly always least advanced in the lambdoid suture.

(4) *Ossa Suturae* (Number of skulls, 547 ♂, 463 ♀).

These were of frequent occurrence, being found in 68% of all male and 69% of all female skulls.

TABLE XII

Ossa suturae							Complete Series	
							♂	♀
Present	-	-	-	-	-	-	68%	69%
Bilaterally	-	-	-	-	-	-	67%	57%
On right only	-	-	-	-	-	-	19%	23%
On left only	-	-	-	-	-	-	14%	20%

It would be tedious and cumbersome to set out in detail the mode of occurrence of these Wormian bones, suffice it to say that they occurred in every possible combination, and occurred alone, unilaterally and bilaterally in the lambdoid, parieto-mastoid and occipito-mastoid sutures.

The bones present were distributed in the following way (Table XIII).

TABLE XIII

Ossa suturae							Complete Series	
							♂	♀
In lambdoid suture	-	-	-	-	-	-	88%	80%
In occipito-mastoid suture	-	-	-	-	-	-	25%	30%
In parieto mastoid suture	-	-	-	-	-	-	24%	22%

In the male skulls examined there were 579 ossicles on the right and 471 in the left lambdoid suture, and in the females 410 in the right and 361 in the left

lambdoid suture. In two male skulls there were a large number of medium-sized bones extending along the whole length of the lambdoid suture, and in three male skulls there were many small ossicles in the lambdoid suture.

Preinterparietal bones occurred in 33 males and 26 female skulls. They were multiple in eight male and ten female skulls, and single in the remainder. One medium-sized sutural bone was present in the pars postica of the sagittal suture in six male and two female skulls, and in one female skull there were five medium-sized ossicles in the posterior part of the sagittal suture and one preinterparietal bone at lambda. A preinterparietal bone occurred without any sutural bones in one male and six female skulls.

Tiny inclusions in the coronal suture were seen bilaterally in 13 male and four female skulls, and a medium-sized ossicle occurred in the coronal suture bilaterally in two male and two female specimens. Each of the following occurred once in female skulls: one medium-sized bone in the right coronal, two small ossicles in the left coronal, and one large bone in the right coronal suture. In three male and two female skulls inclusions occurred only in the coronal suture.

Tiny ossicles occurred in the nasofrontal suture in eleven male and eight female skulls.

A large os bregmaticum occurred in one male Northern Territory skull.

A small ossicle occurred bilaterally at the junction of the zygomatic bone, the frontal bone and the great wing of the sphenoid bone in one male skull, and in the right sphenofrontal suture in one male and one female skull. In another male skull sutural bones occurred along the whole length of the right squamous suture.

Evidence of an os Incae (true interparietal bone) occurred in six male and five female skulls. In two male and two female skulls a single complete os Incae occurred, and in one male cranium a tripartite bone was present. The right two-thirds of the bone occurred in one male and the left two-thirds in one male and one female. The medial third only occurred in one male, and the two lateral thirds only in one female skull.

(5) *Type of the Pterion* (Number of skulls, 401 ♂, 365 ♀).

The frequency of the occurrence of variations in the region of pterion of the Australian has been mentioned by many observers. Table XIV shows briefly the frequency of the various types of contact.

TABLE XIV

Type of pterion	Complete Series	
	♂	♀
Sphenoparietal contact bilaterally	67%	62%
Frontotemporal contact:		
Bilaterally - - - -	4%	4%
On right only - - - -	3.5%	4.4%
On left only - - - -	3.5%	4.4%
Stellate junction unilaterally - -	2.5%	3%
Junction through epipteric bone -	19%	22%

A bilateral stellate junction occurred in one female skull only. The skulls in which epipteric bones occurred are considered more fully in the next section.

Of the sphenoparietal contacts the following details were observed.

TABLE XV

Width of sphenoparietal contact					Complete Series	
					♂	♀
Right = left	-	-	-	-	27%	22%
Right > left	-	-	-	-	35%	35%
Right < left	-	-	-	-	38%	43%

Wherever possible the width of the sphenoparietal contact was measured and the average widths are given below. The contact was classed as narrow when less than 5 mm. wide, usual when 5-10 mm. wide, and large when more than 10 mm. wide. This classification gave the following results:

TABLE XVI

Width of contact					Complete Series		Northern Territory Only	
					♂	♀	♂	♀
Narrow	-	-	-	-	15%	16%	25%	36%
Usual	-	-	-	-	58%	67%	50%	55%
Wide	-	-	-	-	27%	17%	25%	9%
Right side	-	-	-	-	8.1 mm.	7.3 mm.	7.5 mm.	6.3 mm.
Left side	-	-	-	-	8.4 mm.	7.2 mm.	8.1 mm.	5.8 mm.

As well as the sphenoparietal contact being somewhat narrower in the Northern Territory skulls, it was found that the pithecooid (fronto-temporal) contact was more frequent in the Northern Territory series.

TABLE XVII

Pterion		Complete Series		Northern Territory Only	
		♂	♀	♂	♀
Percentage of pithecooid contacts		- 11%	13%	16%	25%

The temporo-frontal contact varied greatly in width. The broadest recorded was 26 mm. for a contact occurring on the right side only, and 21 mm. for a bilateral pithecooid contact. This type of articulation went through all gradations to a stellate contact, the average widths for the whole series, excluding the stellate contacts, being:

Width of contact					Complete Series	
					♂	♀
Right side	-	-	-	-	10.8 mm.	9.5 mm.
Left side	-	-	-	-	10.5 mm.	9.7 mm.

These pithecooid contacts were generally effected through a well-developed frontal process of the temporal bone. In a few cases (the exact number was not

recorded), there was a frontal process of the temporal bone which failed to effect a pithecoïd contact. In one case it was noted that a fronto-temporal contact was apparently due to very small great wings of the sphenoid bone. In another case, where the contact was wide, there was a frontal process of the temporal; a temporal process of the frontal bone, and a small epipteric bone involved in the contact on each side.

(6) *Epipteric Bones* (Number of skulls, 415 ♂, 407 ♀).

Epipteric bones occurred in 24% of the whole series of skulls, equally in males and females. Their distribution and size is indicated in Table XVIII.

TABLE XVIII

				Bilaterally		Right Only		Left Only	
				♂	♀	♂	♀	♂	♀
Of all Australian skulls	-	-	-	7%	9%	11%	8%	6%	7%
Of these: small	-	-	-	24%	—	10%	18%	21%	13%
moderate	-	-	-	41%	60%	53%	68%	37%	66%
large	-	-	-	35%	40%	32%	24%	42%	21%

When they occur unilaterally the other side may have a normal contact, or rarely, a pithecoïd contact, the ratio of normal to pithecoïd contacts being about the same as in the whole series of skulls. Occasionally, when the epipteric bone was small, there was an actual sphenoparietal or fronto-temporal contact present as well; usually, however, the epipteric bone made the whole of the contact. Of the epipteric bones, 33% in the male and 26% in the female were noted as extending back along the anterior part of the squamous suture. In two male and ten female skulls there occurred more than one bone at pterion, four bones being present bilaterally in one female and unilaterally (on right side) in one male and one female skull.

When they occurred bilaterally the epipteric bones were usually of about the same size, considerable differences in size being seen in four skulls only.

(7) *Supraorbital Foramina, Notches or Grooves* (Number of skulls, 667 ♂, 509 ♀).

Supraorbital foramina occurred in only 26% of the series (25% ♂, 28% ♀). Even when they were present there were generally large grooves or notches present as well, the foramen transmitting a small part only of the nerve and vessels. In the remaining skulls notches were present in 61%, and grooves in 40% (no significant sexual difference). In one male and three female skulls there was no trace of a groove, notch, or foramen in the upper orbital margin. Table XIX summarizes the conditions found.

In 10% of the male and 8% of the female skulls in which foramina occurred these were double, this condition occurring bilaterally in one male and one female skull, and in the remainder twice as often on the right as on the left. The second foramen could be described as a foramen of Henle in about half of these cases.

TABLE XIX

Sex	Foramina	Bilaterally Notches	Grooves	Foramen on Right Notch (or Groove) on Left	Foramen on Left Notch (or Groove) on Right	Notch on Right Groove on Left	Notch on Left Groove on Right
♂	- 6%	36%	30%	10%	8%	5%	4%
♀	- 9%	37%	28%	8%	11%	2%	5%

Supraorbital grooves varied in depth from wide deep grooves to very shallow almost imperceptible markings on the upper orbital margin. Of the cases in which grooves occurred their degree of development varied as shown below :

TABLE XX

Supraorbital grooves					Complete Series	
					♂	♀
Very shallow	-	-	-	-	25%	21%
Shallow	-	-	-	-	30%	40%
Moderately deep	-	-	-	-	45%	39%

The supraorbital notches or grooves were generally situated in the medial third of the supraorbital border, foramina occurring a little further laterally.

In no undoubted Australian skull were there any traces of grooves made by the supraorbital nerves on the squamous part of the frontal bone.

(8) *Foramen Ethmoidale Anterius* (Number of skulls, 459 ♂, 403 ♀).

This foramen passed through the fronto-ethmoidal suture more commonly than through the frontal bone, and in no case did it pass completely through the lamina papyracea of the ethmoid bone.

In one female skull the anterior ethmoidal foramen had a frontal exit on the right side, and was absent on the left.

TABLE XXI

Foramen ethmoidale anterius				Complete Series	
				♂	♀
Through suture bilaterally	-	-	-	51%	59%
Through frontal bone bilaterally	-	-	-	39%	28%
Through frontal on right, suture on left	-	-	-	4%	5%
Through frontal on left, suture on right	-	-	-	6%	8%

(9) *Sutures of the Inner Wall of the Orbit* (Number of skulls, 420 ♂, 367 ♀).

A fronto-maxillary contact occurred between the lamina papyracea of the ethmoid and the lacrimal bone in three male and seven female skulls. It was found bilaterally in one male and four females, on the right side only in one male and two females, and on the left side only in one male and one female. This pithecoïd contact varied in width from one to six millimetres (usually 2-3 mm.), and in most cases a frontal process of the maxilla and a maxillary process of the

frontal bone contributed equally to its formation. In one male skull the contact was effected through a frontal process of the maxilla alone.

The lacrimal bone was usually much reduced in these cases, occupying the lower posterior part of the lacrimal canal. No trace of a lacrimal bone could be found in one male Victorian skull, an expanded frontal process of the maxilla making good the deficiency. In this specimen a "lacrimal crest" occurred on the expanded frontal process of the maxilla.

In one male skull (on the left side, normal contact on right), and in one female skull (on the left side, fronto-maxillary contact on right), a long narrow process of the lamina papyracea of the ethmoid bone extended forwards above a reduced lacrimal bone and came into contact with the frontal process of the



Fig. 10

Variations on the inner wall of the orbit
(Shading = accessory bone; e = ethmoid; f = frontal; l = lacrimal; m = maxilla)

maxilla. In one male skull similar contact was effected by the extension backwards of part of the frontal process of the maxilla above a reduced lacrimal bone.

Small accessory bones were present in the neighbourhood of the lacrimo-frontal articulation in one male and two female skulls. Several of these conditions are illustrated in figure 10.

The width of the lamina papyracea of the ethmoid bone in the neighbourhood of the anterior ethmoidal foramen was measured. The average width in male skulls was 12.2 mm., in female skulls 11.6 mm. There was a considerable reduction in the width of the lamina anteriorly, i.e., where it articulated with the lacrimal bone, in 9% of the male and 5% of the female skulls.

Sutural irregularities on the inner wall of the orbit occurred most frequently in Victorian skulls, beyond this no regional variation was found.

(10) *Spheno-maxillary Fissure* (Number of skulls, 459 ♂, 403 ♀).

Three varieties of fissure occurred amongst the Australian skulls, *viz.*: type 1, narrow with parallel sides, type 2, diverging as it was traced forwards, and type 3, slit-like with an expanded anterior extremity.

They were classed as very narrow when their greatest width was less than 3 mm., narrow when between 3 and 5 mm., usual when between 5 and 8 mm.,

wide when between 8 and 12 mm., and very wide when more than 12 mm. Following this division the results obtained were:

TABLE XXII

Spheno-maxillary fissure	Type 1		Complete Series Type 2		Type 3	
	♂%	♀%	♂%	♀%	♂%	♀%
Of these:						
Very narrow (< 3 mm.)	-	67%	67%	—	—	—
Narrow (3-5 mm.)	-	30%	31%	37%	25%	27%
Usual (5-8 mm.)	-	3%	2%	52%	57%	55%
Wide (8-12 mm.)	-	—	—	10%	16%	17%
Very wide (> 12 mm.)	-	—	—	1%	2%	0.5%

Duckworth (9) describes an Australian aboriginal skull with a deficient posterior orbital wall. Those skulls in which the inferior orbital fissure has been classed as very wide (three male and eight female skulls) correspond with Duckworth's "imperfect post-orbital wall."

(11) *The Form of the Orbit* (Number of skulls, 623 ♂, 471 ♀).

The axis of the orbits varied in obliquity between horizontal and strongly oblique, but the commonest condition was a slight obliquity of the axes. In the female skulls obliquity was less pronounced than in the male.

TABLE XXIII

The orbit Axes:	Complete Series	
	♂	♀
Horizontal	7%	17%
Almost horizontal	10%	15%
Slightly oblique	36%	40%
Definitely oblique	42%	25%
Strongly oblique	2%	1%

In 2% of the crania the orbital axes were in the same line, but instead of being horizontal were skewed down to one side (to the right side twice as often as to the left). In two male and three female skulls the axes of the orbits appeared to slope slightly upwards and outwards.

The obliquity of the axes was noted as being unequal in 6% of the male and 3% of the female skulls, and was usually greater in the right side (eight times as often on the right in males and twice as often on the right in females).

The orbits of the Australian aborigine are large, the great cavernous orbits beneath over-hanging brows being one of the striking features of the Australian facial skeleton.

They vary considerably in shape, from a low straight-sided rectangular type to an almost circular condition. Klaatsch says, "The circumference of the orbits offers greater variations than in any other race, from the circular, as in anthro-

poids, to the depressed form." They are usually more angular in the male and more rounded in the female skulls (65% of male and 28% of female skulls being angular rectangular).

TABLE XXIV

Orbital shape	Complete Series			
	Angular Rectangular		Rounded Rectangular	
	♂	♀	♂	♀
Low - - - -	16%	3%	6%	5%
Moderate height - -	40%	14%	22%	41%
High - - - -	9%	11%	6%	24%

The orbit was relatively higher in females than in the males; this is also evident in Hrdlicka's figures.

The orbits were not always a true rectangular shape, they were often (in 15% of all cases, equally in both sexes) higher laterally than medially. This condition was generally associated with a strongly oblique inferior border cutting off the infero-medial angle.

Wunderly and Wood Jones (37) have pointed out that the inferior margin of the orbit provides a useful point for differentiation between Australian and Tasmanian skulls. The inferior margin inclines upward at each end, especially the medial end, in the Australian, and the inferior margin is generally more oblique than the superior orbital margin. To quote these writers: "In the Tasmanian skull the inferior margin is straight over a larger part of its length, and the obliquity of the inferior margin is generally equal to, or only slightly greater than, that of the superior margin. The inferior margin is usually fairly thick and well rounded, while in the Australian it is generally thinner. . . ."

In 4% of all cases the orbits were recorded as being lower laterally than medially. This was noted especially in long, low, rounded orbits approaching an oval in shape. The orbits were noted as being small in 4% of the skulls, and there was no significant sexual difference in this feature.

A feature of the Australian orbit which has attracted attention from several observers (Turner (27), Klaatsch (15), Burkitt and Lightoller (4), Krogman (16)) is the flattened lateral border of the orbit, *i.e.*, the lateral wall and the lateral part of the inferior wall pass round a low flattened border on to the facial surface of the malar bone. This feature was not systematically examined in this series. It was noticed that all degrees of sharpness of this lateral border occurred. In juvenile and some female skulls the border was quite sharp and definite, and in many adult skulls the orbital walls passed over a wide low bevelled edge onto the facial surface of the malar bone. In a few skulls, where the malar tuberosity was strongly developed, the lateral wall of the orbit appeared to be continuous with the facial surface of the malar bone, a slight convexity only intervening between these regions. Klaatsch (15) considered that ". . . where the orbital border of the malar is found to be rounded, without a well-defined boundary for the eye-

cavity, its aboriginal nature can be accepted." The condition of the upper and lower borders was noted and is recorded as rounded or sharp.

TABLE XXV

Upper and lower orbital borders							Complete Series	
							♂	♀
Rounded	-	-	-	-	-	-	45%	12%
Moderately rounded	-	-	-	-	-	-	10%	9%
Sharp	-	-	-	-	-	-	7%	31%
Moderately sharp	-	-	-	-	-	-	18%	31%
Upper border sharp, lower rounded	-	-	-	-	-	-	9%	14%
Upper border rounded, lower sharp	-	-	-	-	-	-	11%	3%

Thus the upper and lower borders of the orbits were generally rounded in male and sharp in female skulls. In female crania, where the upper and lower borders differ, it was generally the upper one which was comparatively sharp. This was related to the supraorbital development in these skulls.

Wood Jones (31) did not include a study of the glabella and supraorbital ridges in his series of morphological features. In view of the importance of this supraorbital region in the formation of the face in the Australian, an attempt has here been made to record the varying conditions found. This subject warrants closer study than can be devoted to it in a general paper such as this, for many of the features depend on two or more factors for their development.

The prominence of glabella was estimated according to Broca's table (Martin (19), p. 873), although the receding forehead in the Australian somewhat modifies the picture. A prominent glabella may be due to a great projection forwards of the actual glabellar region—a visière frontale, a deeply depressed nasion, or, as was usual amongst these skulls, a combination of these two factors. No direct estimation of the relative importance of the two factors was made.

Again, it is not possible in a general paper to discuss in detail the relative development of the glabella and of the supraorbital ridges. Suffice it to say that a prominent glabella combined with relatively flat trigonum supraorbitale occurred fairly frequently, especially in Northern Territory male skulls. The reverse condition, with a great development of the supraorbital torus and only a moderately prominent glabella which then lay in a slight depression between the tori, occurred frequently in the male skulls from South Australia and Victoria.

The supraorbital region was classified as one of Cunningham's three main types (following Martin (19), p. 876). Type 1 proper rarely occurred in this series; the skulls so designated in Table XXVII usually had slight superciliary ridges or none at all, while a moderately deep nasion caused the glabella to appear slightly prominent, although there was no definite protuberance here. A definite margo supra-orbitalis below a crista superciliaris occurs very rarely in Australian crania. The various findings are summarised in Table XXVI.

TABLE XXVI

		Complete Series						Supra-orbital		Supra-glabella		Glabella	
		Supra orbital Region						Torus		Fossa		Suture	
Development:		Type 1		Type 2		Type 3		♂	♀	♂	♀	♂	♀
absent	-	—	—	—	—	—	—	74%	97%	53%	81%	18%	80%
slight	-	3%	21%	—	—	—	—	—	—	—	—	18%	10%
small	-	66%	67%	16%	67%	13%	90%	8%	3%	3%	3%	64%	10%
moderate	-	29%	12%	60%	32%	59%	10%	14%	—	44%	16%	—	—
great	-	2%	—	24%	1%	28%	—	4%	—	—	—	—	—

TABLE XXVII

							Complete Series	
Supraorbital region							♂	♀
Type 1	-	-	-	-	-	-	13%	72%
Type 2	-	-	-	-	-	-	63%	26%
Type 3	-	-	-	-	-	-	24%	2%

TABLE XXVIII

Glabella							Complete Series	
							♂	♀
Broca: I	-	-	-	-	-	-	—	3%
II	-	-	-	-	-	-	9%	48%
III	-	-	-	-	-	-	34%	44%
IV	-	-	-	-	-	-	37%	5%
V	-	-	-	-	-	-	17%	—
VI	-	-	-	-	-	-	3%	—

It is obvious that there is a well-marked sexual difference in the supraorbital region. Strongly developed supraorbital ridges do occur in a few undoubted females (e.g., Burkitt and Hunter (3)), but generally the brow region of the female is almost devoid of superciliary ridges and the prominence of the glabella is due to the depression of nasion. In the males, on the other hand, there is a considerable variation from great overhanging ridges to a relatively slight supra-orbital development similar to the female condition.

A definite torus supraorbitalis was present in 26% of the male and 3% of the female skulls. In 47% of the male and 19% of the female skulls there was a definite depression above the glabella, the fossa supraglabellaris. In many cases this extended laterally, as a concavity above the supraorbital tori. In a small percentage of cases, where the brow region was strongly developed, there was no supraglabellar fossa, although supratatorial depressions were present. This was due to the median frontal ridge filling up the fossa and extending right forward to the glabella. Where the superciliary arches were strongly developed there was usually a distinct jagged glabellar "suture," formed by the fusion of the out-growing masses of bone in the midline. This glabellar "suture" is, of course, quite distinct from the persistent frontal suture (see *Sutures* (4)).

(12) *Infraorbital Foramen* (Number of skulls, 612 ♂, 460 ♀).

The infraorbital foramen was "normal" (i.e., single) bilaterally in 80% of the skulls of both sexes. In 17% of the male and 16% of the female skulls there was a small accessory foramen, usually situated above and medial to the main foramen. The communication of this accessory foramen with the infraorbital canal was in all cases determined by the passage of a fine wire, in order to exclude occasional venous foramina occurring in this neighbourhood.

In 5% of the male skulls (34 specimens) and 3% of the female skulls (15 specimens) a true pithecoïd exit of the infraorbital canal, generally double, was present. In one male skull the pithecoïd exit was represented by three foramina on each side, all of approximately the same size. A few of the cases recorded as "accessory foramina" were larger than usual and probably represent a development intermediate between the tiny medial accessory foramen and the pithecoïd condition of multiple exit.

Of these skulls wherein the infraorbital foramina were described as pithecoïd, there was a septate condition of the anterior part of the infraorbital canal in five male and five female skulls. In these a fine vertical septum of bone divided the anterior part of the infraorbital canal into two parts. The septum was obviously visible from norma facialis in only two of these skulls. In the remainder it stopped just short of the exit of the canal, which in some of these cases looked downwards rather than forwards, due to the deep excavation of the infraorbital fossa. This latter condition is discussed more fully below.

TABLE XXIX

	Complete Series			
	Accessory Medial Foramen		Pithecoïd Exit	
	♂	♀	♂	♀
Present in:	17%	16%	5%	3%
Of these—				
bilaterally - -	30%	32%	24%	—
on right only - -	34%	36%	52%	27%
on left only - -	36%	32%	24%	73%

Combinations of pithecoïd exits and small medial accessory foramina occurred in a few skulls. In three male and one female skull there was a pithecoïd exit on one side (the left in all save one male) and a normal exit with a small medial accessory foramen on the other. In one male skull there was a pithecoïd (double) exit and a small accessory foramen on the right and a normal exit and accessory foramen on the left. In one male and one female skull there were two tiny medial accessory foramina on both sides.

In 24% of the male and 44% of the female skulls there was present a suture passing from the infraorbital foramen over the orbital margin and inferior wall of the orbit to the posterior part of the inferior orbital canal. In a few cases the

facial part of this suture ended in the junction of the lacrimal bone with the orbital plate of the maxilla. The orbital part of the suture then passed from the posterior end of this lacrimo-maxillary articulation to the posterior uncovered part of the infraorbital canal. Occasionally the facial part of the suture extended from the infraorbital foramen to the malo-maxillary suture, and on the orbital plate of the maxilla another suture passed from the malo-maxillary suture to the infraorbital canal. When an accessory medial foramen was present the facial part of the suture sometimes arose from this foramen, sometimes passed from the main foramen through the accessory foramen to the orbital margin, and sometimes appeared to effect no connection with the accessory foramen.

Klaatsch (15) noted that "in R. 62 a slight prominence tends to divide the foramina, a variation which may prove important, because in anthropoids it is more common to find two infraorbital foramina than one." This feature was noticed in quite a number of skulls, but it does not appear to represent an attempt to subdivide the foramen. It occurs where a finely dentate infraorbital suture arises from the infraorbital foramen. The suture is prolonged down below the margin of the infraorbital foramen in the centre of a slight projection of bone. In all cases in which this projection was present (including R. 62) it was associated with a trace of the suture.

It appears that when the infraorbital suture was finely dentate it tended to persist into adult life, whilst a linear type of suture, such as was present in many juvenile skulls, usually fused early.

TABLE XXX

				Complete Series	
				♂	♀
Infraorbital suture present	-	-	-	24%	44%
Of these bilaterally	-	-	-	66%	74%
on right only	-	-	-	18%	12%
on left only	-	-	-	16%	14%

The infraorbital canal was completely roofed in from the lower orbital margin to the speno-maxillary fissure in one male and one female skull, this condition occurring bilaterally.

The facial surface of the maxilla varies somewhat in aboriginal skulls. There may be an "infraorbital fossa" consisting of the infraorbital fossa proper and the canine fossa, which cannot be distinguished from it. This common large fossa varies in form from a large shallow depression to a large or small deep fossa. The two fossae may be present and separated by a small bony prominence, and either infraorbital or canine fossa may be present alone. In a few skulls the facial surface of the maxilla was quite flat and in one female skull it was definitely convex, giving a peculiar appearance to the face.

The form of the fossa on the facial surface of the maxilla was noted in 289 male and 238 female skulls (Table XXXI). In the remaining skulls it was generally a large rather shallow concavity, sometimes divided by an osseous prominence into upper and lower parts.

Burkitt and Hunter (3) have attempted to explain the infraorbital fossa by considering it to be a concavity between two bony buttresses developed in response to the thrust from the canine and incisor teeth and the molar teeth, respectively. As they pointed out, there is also, in a large number of cases, an actual excavation of the fossa, which is remarkably pronounced in some specimens, so that the inferior orbital border projects forward like a shelf above the deep fossa, and the infraorbital foramen faces directly downwards.

TABLE XXXI

"Infraorbital" fossa:					Complete Series	
					♂	♀
Large and deep	-	-	-	-	28%	27%
Large and moderately deep	-	-	-	-	11%	15%
Shallow	-	-	-	-	26%	17%
Moderate size and depth	-	-	-	-	27%	26%
Small and deep	-	-	-	-	8%	15%

(13) *The Form of the Jugal* (Number of skulls, 629 ♂, 478 ♀).

In no skull of this series was there any trace of a divided malar bone. In the description of the shape of the malar bone given below "angular" was applied to a bone in which the anterior part of the facial surface looked forwards, and made an angle with the lateral and posterior part of the bone; "rounded" applied to cases in which this angle was gently rounded off, and "flat" to those in which the whole external surface of the bone made a fairly flat plane facing antero-laterally.

TABLE XXXII

Malar bone:					Complete Series	
					♂	♀
Shape: angular	-	-	-	-	20%	6%
rounded	-	-	-	-	51%	64%
flat	-	-	-	-	29%	30%
Size: small	-	-	-	-	4%	37%
moderate	-	-	-	-	75%	61%
large	-	-	-	-	21%	2%

The lower margins of the zygomatic bones were generally everted, but occasionally they appeared parallel when the skull was viewed from the facial aspect. The inferior border of the bone was usually convex downwards, but was sometimes straight. It usually formed a flat rather rough surface for the attachment of the strong masseter muscle. The occurrence of these various conditions is summed up in Table XXXIII.

TABLE XXXIII

					Complete Series	
Inferior border of malar bones:					♂	♀
Everted and convex	-	-	-	-	77%	75%
Everted and straight	-	-	-	-	15%	20%
Parallel and convex	-	-	-	-	4%	2%
Parallel and straight	-	-	-	-	3%	3%

In Australian skulls the malar tuberosity takes the form of a prominent ridge on the malar surface of the bone running parallel with the inferior border. This development is much more marked in male skulls. In many of the female skulls it was not developed at all (Table XXXIV).

TABLE XXXIV

Malar tuberosity— Development:					Complete Series	
					♂	♀
Absent	-	-	-	-	8%	45%
Slight	-	-	-	-	14%	26%
Small	-	-	-	-	35%	22%
Moderate	-	-	-	-	30%	6%
Great	-	-	-	-	13%	1%

Klaatsch (15), Burkitt and Hunter (3), Turner (27) and others have commented on the prominence of this malar tuberosity, and noticed that when it was very strongly developed the floor of the orbit passed out on to the facial surface of the malar bone, so that there was only a rounded bevelled orbital border. Burkitt and Hunter attempted to correlate the development of this bony ridge with the wear of the molar teeth, and considered that it was a mechanical strut developed in response to the thrust from the molar teeth.

The angle between the superior border of the temporal process and the posterior border of the fronto-sphenoidal process was 90° in 40% of the skulls, less than 90° in 50%, and more than 90° in the same number. There was no sexual difference. This angle is correlated with, but not absolutely dependent upon, the development of the marginal process. The degree of development of this bony tubercle is indicated in Table XXXV.

TABLE XXXV

Marginal process— Development:					Complete Series	
					♂	♀
Absent	-	-	-	-	0.7%	3%
Slight	-	-	-	-	6%	16%
Small	-	-	-	-	25%	32%
Moderate	-	-	-	-	42%	39%
Great	-	-	-	-	28%	10%

Krogman (16) drew attention to the concavity of the inferior margin of the maxilla, so that the facial aspect of the malo-maxillary suture was situated on a downward projection lateral to the concavity. A glance at a few skulls of other races indicated that this condition is common amongst them. Records were kept of the form of the inferior border of the zygomatic process of the maxilla, it being termed "normal" when the curve of its lower border formed an arc of less than one-quarter of a circle, and "concave" when the malo-maxillary suture was situated on a downward projection as described by Krogman.

TABLE XXXVI

Zygomatic process of maxilla:	Complete Series	
	♂	♀
"Normal" bilaterally - - - -	47%	70%
"Concave" bilaterally - - - -	47%	22%
Normal in right; concave in left - -	3%	4%
Normal on left; concave on right - -	3%	4%

The greater number of concave lower borders in the male skulls is correlated with the larger and more massive build of the zygomatic bone in that sex. There is some regional variation in the frequency of occurrence of this concave lower border to the maxilla, it being much more common in the Northern Territory and the Queensland series—77% in Queensland males and 70% in Northern Territory males, compared with 37% in male skulls from Victoria, New South Wales and South Australia. The females from the two northern groups show a similar higher incidence than the southern females.

The diamond-shaped face of the Australian is brought about by a broadening of the cheek region (with large malar bones facing antero-laterally) and a lateral convexity of the zygomatic arch, so pronounced that in many skulls, especially those from the southern States, the greatest breadth of the skull is that between the two most prominent points of the zygomatic processes of the temporal bones.

The zygomatic arches of the Australian are thick and heavy, a useful point of differentiation from Tasmanian crania, where they are very light (as Wunderly and Wood Jones pointed out); and they are generally quite strongly convex upwards.

(14) *Nasal Bones* (Number of skulls, 584 ♂, 442 ♀).

The nasal region of the Australian aborigine is one of the most typical parts of the facial skeleton. The low, rounded, saddle shaped bridge of the nose is well known and was invariably present.

Viewed from norma facialis the nasal bones are usually shaped like an hour-glass, constricted in the middle. Sometimes there was no such constriction and the sides of the nasal bones were then either parallel or diverged below. They have been classified as wide (smallest width of the two bones more than 12 mm.), usual (smallest width between 10 and 12 mm.), and narrow (smallest width less than 10 mm.).

TABLE XXXVII

	Constricted in Middle		Complete Series Not Constricted in Middle Parallel Sides		Not Constricted in Middle Diverging Sides	
	♂	♀	♂	♀	♂	♀
Nasal bones:						
Of all skulls - -	88%	80%	9%	15%	3%	5%
Of these: Wide -	16%	12%	19%	18%	21%	24%
Usual -	50%	28%	46%	39%	53%	52%
Narrow	34%	60%	35%	43%	26%	24%

Measurements were made of the widths of the two nasal bones at the fronto-nasal suture, at their narrowest, and at their widest parts. The average dimensions thus determined were:—

TABLE XXXVIII⁽³⁾

Nasal bones:	Complete Series	
	♂	♀
Upper breadth (57 (2)) - -	11.9 mm.	11.1 mm.
Smallest breadth (57) - -	9.6 mm.	9.2 mm.
Lower breadth (57 (3)) - -	17.6 mm.	16.7 mm.

The nasal bones were slightly narrower in all measurements in the Northern Territory and Queensland crania, especially the female skulls. In one male and three female skulls the upper breadth, measured from the extremities of the fronto-nasal suture, was the greatest.

The two nasal bones were not always the same size; when they were unequal the right side was wider than the left somewhat more commonly than was the reverse. Where there was such an inequality it was confined to the upper part of the nasal bones in 9% of the male and 6% of the female cases.

TABLE XXXIX

Nasal bones:	Complete Series	
	♂	♀
Right > left - - - - -	35%	40%
Right = left - - - - -	39%	33%
Right < left - - - - -	26%	27%

The inequality above was so great as to exclude one nasal bone from articulation with the frontal bone in two male and three female skulls. In all except one male specimen it was the right nasal bone which articulated with the frontal bone.

The internasal suture was generally of linear form throughout its length, although the upper part was often slightly dentate. It was recorded as finely dentate throughout in 2% of the male and 3% of the female skulls, and showed

⁽³⁾ The numbers after the measurements in Table XXXVIII refer to the reference numbers of Martin (19), 2, p. 661

some degree of synostosis in a surprisingly large number of specimens. Synostosis seemed usually to begin at its upper end. Table XL sets out the observations made on the internasal suture. "Partly synostosed" indicates more advanced fusion than a synostosis of the upper part only of the suture.

TABLE XL					Complete Series	
Internasal suture:					♂	♀
Not synostosed: linear					61%	78%
finely dentate					2%	3%
Completely synostosed					9%	5%
Partly synostosed					14%	9%
Synostosed above only					14%	5%

Some of the skulls in which there was a complete fusion of the internasal suture were those of old persons with advanced synostosis of the sutures of the cranial vault. In 50% of the male and 35% of the female specimens with complete obliteration of the internasal suture, however, fusion in the coronal, sagittal and lambdoid sutures was just beginning. There was no evidence of any fusion of the sutures of the vault in 21% of the male and 33% of the female skulls in which synostosis had commenced in the upper part of the internasal suture.

In two male skulls there was present in the upper part of the internasal suture, between the two nasal bones and the frontal bone, a definite ossicle measuring about 5 mm. x 4 mm., forming a small os internasale.

The nasofrontal suture was usually convex upwards. When the curve of the nasofrontal suture between its two extremities described approximately a semi-circle, or was even more convex, it was recorded as "high." Where it described a low curve, forming only a small arc of a circle, it has been called "low." In a few cases the nasofrontal suture was straight or even concave upwards.

TABLE XLI					Complete Series	
Nasofrontal suture:					♂	♀
Low					47%	47%
High					52%	50%
Slightly concave					0.3%	3%
Linear					24%	24%
Finely dentate					73%	75%
Partly synostosed					3%	0.6%

The nasofrontal suture was generally finely dentate, sometimes linear, and was in a few cases partly synostosed.

Small ossicles were sometimes found in the nasofrontal suture, the details of the occurrence being given under *Ossa Suturarum* (4).

In one male skull from South Australia medial extensions of the frontal processes of the maxillae excluded the nasal bones from articulation with the frontal bone.

The curve of the nasal bones when viewed from norma lateralis were classified according to Martin's three types (p. 946), although owing to the low bridge the concavity was usually greater than Martin represents.

TABLE XLII					Complete Series	
Nasal bones—lateral view:					♂	♀
Martin's type 1	-	-	-	-	16%	10%
„ „ 2	-	-	-	-	68%	72%
„ „ 3	-	-	-	-	16%	18%

Very small nasal bones occurred in one female skull, and in one female specimen with a very slight development of the nasalia there appeared to be only one bone present between the frontal processes of the two maxillae.

There was a peculiar condition in one male Victorian skull. The nasofrontal suture could not be clearly distinguished and a single piece of bone, 5 mm. wide in the region of the fronto-maxillary contact, 3 mm. wide at its narrowest part, and 5 mm. wide at the lower end of its junction with the maxillae, took the place of the nasal bones. There was a compensating increase of the frontal processes of the maxillae. The central spike of bone projected freely forwards for 10 mm. from its junction with the maxillae.

(15) *The Narial Aperture* (Number of skulls, 624 ♂, 471 ♀).

The narial aperture in the Australian is large and wide and its shape can best be described as ovoid. There are many variations in the shape of the aperture, but they are difficult to analyze and of doubtful morphological significance. Sometimes it is more definitely oval, sometimes pyriform, sometimes almost triangular.

The average greatest width of the pyriform aperture in the whole series was 27.3 mm. in the male and 25.9 mm. in the female. There were slight regional differences, the New South Wales and Victorian crania having the widest and the South Australian crania the narrowest narial apertures.

The aperture was classed as wide when more than 27 mm. across, as narrow when less than 25 mm. wide, and as usual when its width lay between 25 and 27 mm.

TABLE XLIII					Complete Series	
Narial aperture:					♂	♀
Narrow (< 25 mm.)	-	-	-	-	9%	22%
Usual (25-27 mm.)	-	-	-	-	44%	61%
Wide (> 27 mm.)	-	-	-	-	47%	17%

The lower narial margin is a region of great importance in racial anatomy, and its conformation in the prognathous Australian is of particular interest.

Macalister (18), in his analysis of the lower narial margin, described the paraseptal ridge and its lateral continuation, the anterior dental ridge, as forming the posterior border of the prenasal fossa. Klaatsch called this border the *margo infranasalis*, and named the anterior border of the area or fossa prenasalis the *crista prenasalis*. The *crista prenasalis* is the continuation medially of the lateral border of the pyriform aperture.

Burkitt and Lightoller (4), analysing these features amongst the Australian and other races, were struck by the great variability of their development in the Australian. They sought to explain these variations on mechanical lines—"variations in the area prenasalis and the lower margin of the apertura pyriformis are due chiefly to tooth pressure of the upper incisor or canine teeth," and they visualise the prenasal crest as acting as a buttress or strut. Of the *margo infranasalis* they say that "while its paraseptal portion is probably related to tooth pressure, the anterior dental portion may or may not be."

Johnson (14) has recently advanced another explanation of the causes and significance of these ridges. His explanation is of some interest to us in that it attaches to these features a biological and morphological significance which Burkitt and Lightoller's mechanical explanation does not. Briefly, the *crista prenasalis* represents the advancing edge of the incisor crest of the maxilla, while the *margo infranasalis* is "the anterior edge of the premaxilla passing from the nasal spine laterally along the floor of the nasal fossa, up which it extends as far as the ridge for the inferior concha." After considering the comparative anatomy of the region in the primates and the various human races, he concludes that "in the prognathous types of man the margins (of the narial apertures) are formed by the maxilla and premaxilla in degree varying according to the amount of sub-nasal prognathism, whilst, in the orthognathous white, the narial margins are completely maxillary." Most of the specimens in this series were examined before the publication of Johnson's work.

In the Australian the lateral borders of the narial apertures are sharp. As they turn medially at the lower narial margin to become the *crista prenasalis* or incisor process of the maxilla, one of several things may happen to them. Generally the *crista prenasalis* of the Australian becomes rounded and disappears on the alveolar part of the maxilla vertically above the roots of the lateral and medial incisor teeth. Sometimes the crest can be traced right to the midline as a faint ridge. Sometimes it is more prominent and seems to fuse with the medial part (Macalister's paraseptal ridge) of the *margo infranasalis*. This leads to a moderately sharp lower narial margin shutting off the nasal cavity from the face and simulating the European condition. In a few cases the *crista prenasalis* could be definitely traced medially as two indistinct ridges, a few millimetres apart, to the midline. Sometimes, when this division of the prenasal crest occurs, the anterior part of it disappears on the alveolar border over the incisor teeth, while the posterior ridge continues medially to the midline. The frequency of occurrence of these various forms of *crista prenasalis* is summarized below.

TABLE XLIV

Crista prenasalis:	Complete Series	
	♂	♀
Crest disappears over lateral incisors -	49%	66%
" " " medial " -	17%	10%
Crest traceable faintly to midline -	31%	22%
Crest becomes 2 faint ridges, each passing to midline - - -	2%	1%
Crest 2 becomes faint ridges—posterior passing to midline, anterior disappearing over medial incisor	1%	0.4%

There was a similar variability in the margo infranasalis. There was no trace of it (at least in its medial part, the paraseptal ridge) in 27% of the skulls of both sexes, and its development amongst the remainder varied considerably. In 5% of the skulls a rounded transversely directed elevation replaced the margo infranasalis.

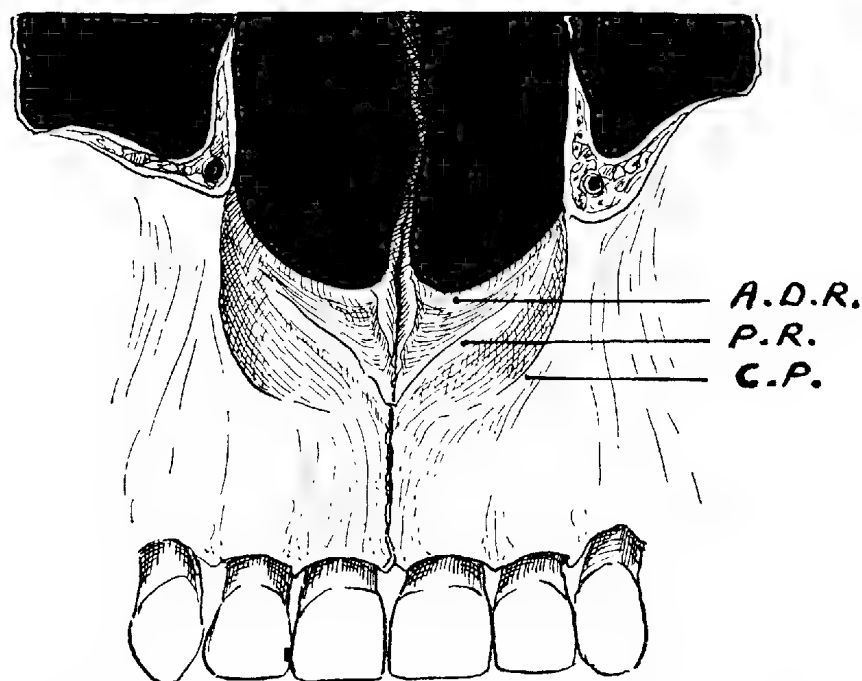


Fig. 11

Diagram showing the various parts of the lower narial margins mentioned in the text (F.W.J.)

C.P. = crista prenasalis; P.R. = paraseptal ridge;
A.D.R. = anterior dental ridge

Macalister (18) and Burkitt and Lightoller (4) both mention that the anterior dental ridge "is often channelled and contains the anterior superior alveolar nerves and vessels to the incisor teeth." Johnson does not mention this,

but it is obvious in many Australian skulls. The canal in the anterior dental ridge can often be traced from the incisor crest just in front of the incisive foramen medially to the anterior part of the lateral wall of the nasal cavity, just below the ridge for the inferior concha and just behind the lateral narial margin. Wood Jones (35) has recently clarified the anatomy of the anterior superior alveolar nerve and vessels and has shown that this canal in the anterior dental ridge is the anterior end of the *canalis sinuosus* in which these anterior superior alveolar nerve and vessels course.

The paraseptal ridge seems to arise from the middle of the anterior dental ridge as it courses across the floor of the nasal cavity. The medial part of the anterior dental ridge is often barely distinguishable and the anterior dental ridge and paraseptal ridge then appear continuous, forming the *margo infranasalis* of Klaatsch. Figure 11 is a diagrammatic sketch of these elements.

The development of the *margo infranasalis* is summed up in Table XLV.

Together, the *margo infranasalis* and the *crista prenasalis* determine the form of the lower narial margin. Table XLVI summarizes the types of margin that occur amongst the Australians following the definitions given in Martin (19). The various descriptive names given for different types of narial margin are not of much morphological significance, they are merely convenient methods of indicating the degree of encroachment of the incisor process of the maxilla over the anterior edge of the premaxilla in the region of the lower narial margin. Where the prenasal crest fades into the alveolar process of the maxilla over the lateral incisor teeth and the *margo infranasalis* cannot be distinguished in the floor

TABLE XLV

Margo infranasalis:							Complete Series	
Development:							♂	♀
Absent	-	-	-	-	-	-	27%	26%
Slight	-	-	-	-	-	-	16%	10%
Small—rounded	-	-	-	-	-	-	27%	26%
Small—sharp	-	-	-	-	-	-	14%	18%
Moderate—rounded	-	-	-	-	-	-	5%	4%
Moderate—sharp	-	-	-	-	-	-	6%	6%
Round transverse elevation	-	-	-	-	-	-	5%	5%

of the nasal cavity, the lower narial margin is described as a pithecoïd groove. If there is a transversely directed rounded elevation separating the nasal cavity from the face, the condition is described as the *clivus nasoalveolaris*. A prominent *margo infranasalis* and a prenasal crest disappearing over the lateral or medial incisors constitute the infantile condition, and if both prenasal crest and *margo infranasalis* can be traced to the midline, prenasal fossae can be distinguished.

The "European" form of lower narial margin is the high sharp crest, extending from the lateral narial margins to the anterior nasal spine, and shutting the interior of the nasal cavity off from the face. This trenchant rising edge is formed

TABLE XLVI

Lower narial margin:					Complete Series	
					♂	♀
Pithecoïd groove	-	-	-	-	16%	18%
Infantile form	-	-	-	-	21%	32%
Prenasal fossae	-	-	-	-	21%	9%
Pseudo-European type	-	-	-	-	25%	22%
Clivus nasopalveolaris	-	-	-	-	17%	19%

of the confluent lateral margin and paraseptal line and masks the anterior dental ridge. This formation, typical of the European, never occurs in Australians. The pseudo-European in Table XLVI refers to a condition in which either the crista prenasalis is traceable as a definite ridge to the anterior nasal spine, and the margo infranasalis cannot be made out (in 79% of the cases); or the crista prenasalis fuses with the anterior part of the margo infranasalis (paraseptal ridge) to produce a similar effect (21% of the cases). In all cases there is a fine ridge only, never the sharp edge shutting the nasal cavity off from the alveolar process.

In a few crania, namely those in which the crista prenasalis was definitely bifid, and a margo infranasalis was present, two shallow prenasal fossae could be distinguished on either side.

The degree of development of the anterior nasal spine was estimated according to the table of Broca (Martin, p. 948). In many cases, when the margo infranasalis was absent in its medial part, the anterior nasal spine appeared to project straight forwards from the incisor crest of the maxilla.

TABLE XLVII

Anterior nasal spine:					Complete Series	
					♂	♀
Absent	-	-	-	-	2%	1%
Very slight	-	-	-	-	7%	9%
Broca 1	-	-	-	-	61%	66%
.. 2	-	-	-	-	24%	21%
.. 3	-	-	-	-	4%	3%
.. 4	-	-	-	-	0.5%	-

(16) *The Nasal Septum* (Number of skulls, 336 ♂, 276 ♀).

The condition of the nasal septum is shown in Table XLVIII. It will be seen that the Queensland crania had a much higher proportion of the primitive median nasal septum.

TABLE XLVIII

Nasal septum:		Complete Series		Queensland Only	
		♂	♀	♂	♀
Median	-	39%	41%	62%	63%
Deviated to the right	-	32%	38%	16%	26%
Deviated to the left	-	29%	21%	22%	11%

(17) *Foramen Ovale* (Number of skulls, 618 ♂, 488 ♀).

There is a considerable degree of variation in the region of the foramen ovale in Australians, and these variations can best be set out in tabular form (Tables XLIX, L, LI). The foramen ovale was complete in 89% of the male and 90% of the female skulls. Of these complete ones, 7% of the male and 8% of the female specimens showed sutures passing to the foramen spinosum or to the foramen lacerum, while 6% of the male and 9% of the female skulls were bounded medially (from foramen lacerum) or posteriorly (from foramen spinosum) by a thin spicule of bone.

TABLE XLIX

					Complete Series	
Foramen ovale:					♂	♀
Complete bilaterally in	-	-	-	-	89%	90%
Of these: small	-	-	-	-	11%	23%
usual	-	-	-	-	76%	71%
large	-	-	-	-	13%	6%
Right > left	-	-	-	-	27%	25%
Right < left	-	-	-	-	22%	22%

TABLE L

					Complete Series	
Foramen ovale:					♂	♀
Incomplete foramen ovale in	-	-	-	-	11%	10%
Of these: Communicates medially						
with F. lacerum	-	-	-	-	51%	41%
Bilaterally in	-	-	-	-	35%	15%
On right only in	-	-	-	-	40%	50%
On left only in	-	-	-	-	25%	35%
Communicates posteriorly						
with F. spinosum	-	-	-	-	23%	33%
Bilaterally in	-	-	-	-	13%	25%
On right only in	-	-	-	-	27%	25%
On left only in	-	-	-	-	60%	50%
Communicates with						
F. spinosum and						
F. lacerum	-	-	-	-	26%	26%
Bilaterally in	-	-	-	-	8%	16%
On right only in	-	-	-	-	59%	38%
On left only in	-	-	-	-	33%	46%

In the classification according to size a foramen measuring about 6 mm. x 4 mm. was taken as "usual." Some hundreds of foramina were measured, and eventually it was possible to grade the size of the foramen with considerable accuracy merely by inspection. "Large" and "small" describe foramina noticeably bigger or smaller than the "usual" (6 mm. x 4 mm.) type. Of these complete

foramina, 3% (of both sexes) were circular in shape, and 2% of the male and 0.5% of the female were noted as being very narrow ovals. One male and one female skull had "hour-glass" foramina, and the long axes of the foramina in one male skull were transverse.

TABLE LI

Foramen ovale:				Complete Series	
(Of complete foramina:				♂	♀
Suture to foramen lacerum	-	-	-	3%	2%
Bilaterally in	-	-	-	27%	43%
On right only in	-	-	-	46%	43%
On left only in	-	-	-	27%	14%
Suture to foramen spinosum	-	-	-	4%	6%
Bilaterally in	-	-	-	21%	43%
On right only in	-	-	-	61%	28%
On left only in	-	-	-	18%	27%
Thin plate of bone posteriorly (from					
F. spinosum)	-	-	-	5%	8%
Bilaterally in	-	-	-	4%	33%
On right only in	-	-	-	50%	32%
On left only in	-	-	-	46%	35%
Thin plate of bone medially (from					
F. lacerum)	-	-	-	1%	1%
Bilaterally in	-	-	-	57%	17%
On right only in	-	-	-	14%	50%
On left only in	-	-	-	29%	33%

Analysing the figures in another manner, we find that there is a tendency to a deficiency medially (actual deficiency, suture, or thin plate) in 11% of all male and 9% of all female skulls. There is a tendency to a deficiency posteriorly in 11% of male and 16% of female crania.

(18) *The Foramen of Vesalius* (Number of skulls, 594 ♂, 464 ♀).

In Australian skulls the foramen of Vesalius, when it occurs, lies on a long slit which is situated medial to the anterior end of the foramen ovale. The slit was present when there was no complete foramen of Vesalius.

TABLE LII

Vesalian slit.				Complete Series	
Development:				♂	♀
Bilaterally absent	-	-	-	9%	6%
slight	-	-	-	9%	8%
moderate	-	-	-	76%	82%
Present on right only	-	-	-	2%	2%
Present on left only	-	-	-	4%	2.5%

Augier (in Poirier, Charpy and Nicolas (22)) describes the foramen of Vesalius as being formed of two parts, one inferior and one superior. In the adult, he says, the upper part is frequently obliterated, leaving only the inferior part. Thus the exocranial opening of the foramen of Vesalius may be present when the endocranial opening is absent. By passing a fine wire along the canal it was determined whether or not the inferior opening of the Vesalian canal communicated with the superior part and opened within the cranial cavity. Where the inferior part only was present, the foramen was recorded as incomplete, where the wire could be passed right along the canal it was called complete.

TABLE LIII

Foramen of Vesalius:					Complete Series	
					♂	♀
Complete foramen bilaterally	-	-	-	-	42%	44%
Incomplete foramen bilaterally	-	-	-	-	44%	43%
Of these: size i	-	-	-	-	83%	83%
size ii	-	-	-	-	17%	17%
Absent bilaterally	-	-	-	-	9%	9%
Absent on left, incomplete on right	-	-	-	-	2.5%	3%
Absent on right, incomplete on left	-	-	-	-	3%	1.7%

Where foramina were present their size was measured by determining the largest size of wire which could be passed through them. This also ensured that the foramen under examination was a complete one. The sizes recorded are as below:

size i	admits wire	0.25 mm.	diameter
size ii	.. ..	0.50 ..	..
size iii	.. ..	1.00 ..	..
size iv	.. ..	2.00 ..	..

TABLE LIV
Complete foramina of Vesalius.

			Complete Series					
			Bilaterally		On Right Only		On Left Only	
			♂	♀	♂	♀	♂	♀
Present	-	-	53%	58%	20%	13%	27%	29%
Of these: size i			34%	21%	40%	41%	34%	51%
size ii			46%	54%	43%	39%	47%	28%
size iii			19%	24%	17%	17%	19%	21%
size iv			1%	1%	—	3%	—	—

TABLE LV

Complete foramina of Vesalius:					Complete Series	
					♂	♀
Right = left	-	-	-	-	55%	50%
Right > left	-	-	-	-	17%	19%
Right < left	-	-	-	-	28%	31%

Wood Jones (31) says, "It (the foramen of Vesalius) may be present in some form or other on only one side of the skull; in such cases the size of the foramen ovale is usually notably different upon the two sides being larger on the side on which the foramen of Vesalius is lacking." Where there was obvious inequality in the size of the two foramina of Vesalius this condition was noted (Table LV), and in each case the correlation with the size of the foramen ovale was determined. The results shown in Table LVI were obtained.

TABLE LVI

Correlation between size of F. ovale and F. vesalius:		Complete Series	
		♂	♀
Larger foramina on same side	-	41%	33%
Large foramina on opposite sides	-	59%	67%

Where a complete foramen of Vesalius was present on one side only, the foramen ovale was larger on the opposite side in 33% of male and 26% of female skulls, the reverse was the case in 33% of male and 31% of female skulls, the foramen ovale being approximately the same size in the remaining cases.

These results suggest, that in the Australian at least, the occurrence or not of a foramen of Vesalius is without much effect in the size of the foramen ovale, which is notably large in Australian skulls.

(19) *The Foramen Spinosum* (Number of skulls, 642 ♂, 484 ♀).

The foramen spinosum was complete in both sides of 46% of the male and 36% of the female Australian skulls. In the other skulls all combinations of completeness of the foramina existed. In a few skulls there was no trace of a foramen spinosum (Table LVIII), whilst in others the foramen was represented by a notch. Where the foramen was more distinct than a notch all degrees of imperfection of its medial wall existed. It was sometimes incomplete in the

TABLE LVII

Foramen spinosum.		Complete Series	
		♂	♀
Complete	- - - - -	74%	69%
Of these: Bilaterally	- - -	62%	52%
On right only	- - -	17%	26%
On left only	- - -	21%	22%

TABLE LVIII

Foramen spinosum:	Complete Series							
	Absent		Notch Only		Incomplete Medially		Incomplete Anteriorly	
	♂	♀	♂	♀	♂	♀	♂	♀
Of whole series	3%	3%	6%	3%	21%	26%	3%	5%
Bilaterally -	21%	21%	27%	44%	29%	28%	14%	13%
On right only	53%	50%	38%	31%	41%	32%	38%	32%
On left only -	26%	29%	35%	25%	30%	40%	48%	55%

whole of its length, sometimes incomplete save for a plate of bone in the upper, the middle, or the lower part of the medial wall, and sometimes communicated anteriorly with the foramen ovale. The occurrence of these various conditions is summarized in Tables LVII, LVIII and LIX.

TABLE LIX

Foramen spinosum:	Complete Series, Incomplete Medially							
	Except Above		Except in the Middle		Except Below		In the Middle	
	♂	♀	♂	♀	♂	♀	♂	♀
Of whole series	20%	25%	1%	4%	2%	4%	5%	6%
Bilaterally -	27%	32%	—	17%	13%	11%	27%	19%
On right only	42%	37%	60%	50%	27%	42%	29%	25%
On left only -	31%	31%	40%	33%	60%	47%	44%	56%

Considering all forms of the foramen spinosum, we find that the conditions were symmetrical in 62% of the male and 56% of the female skulls.

The relationships of the foramen to the angular spine of the sphenoid bone was noted in the majority of cases. As will be explained in the next section,

TABLE LX

Relation of F. spinosum to angular spine of sphenoid:	Complete Series							
					♂		♀	
Anterior to spine -	-	-	-	-	-	65%	-	61%
Lateral to spine -	-	-	-	-	-	10%	-	9%
Medial to spine -	-	-	-	-	-	7%	-	10%
Through spine -	-	-	-	-	-	18%	-	20%

the angular spine of the sphenoid was frequently bifid, or ridge-like, and the foramen passed between the two spines—these have been classified as passing through the angular spine of the sphenoid.

(20) *The Spina Angularis Sphenoidi* (Number of skulls, 632 ♂, 486 ♀).

There was no sign of a spine of the sphenoid on either side in five male and four female skulls. In five male and seven female skulls there was a small spine

TABLE LXI

Angular spine of the sphenoid bone:	Complete Series							
					♂		♀	
Present Bilaterally	-	-	-	-	-	98%	-	97%
Very small	-	-	-	-	-	15%	-	23%
Small	-	-	-	-	-	40%	-	42%
Moderate	-	-	-	-	-	37%	-	28%
Large	-	-	-	-	-	6%	-	4%
Right > left	-	-	-	-	-	14%	-	10%
Right < left	-	-	-	-	-	13%	-	11%

on the right but none on the left, and in three skulls of each sex the reverse condition obtained.

It generally took the form of a small, blunt pointed spine projecting down 5-10 mm. from the angle of the sphenoid. Occasionally it took on different forms and the frequency of these is shown in Table LXII.

TABLE LXII

Shape of angular spine of the sphenoid:	Complete Series	
	♂	♀
Usual - - - - -	55%	68%
Blunt - - - - -	11%	8%
Ridge - - - - -	11%	7%
Sharp and fine - - - - -	5%	7%
General elevation of angle - - - - -	7%	3%
Irregular - - - - -	3%	4%
Heavy - - - - -	8%	3%

In one male South Australian skull there was no true spina angularis sphenoides on the right side, but a small spine was developed on the neighbouring part of the temporal bone, like the spina angularis temporalis of the gorilla skull. The conformation on the left side was normal.

(21) *Laminae Pterygoidei* (Number of skulls, 620 ♂, 470 ♀).

The pterygoid laminae of the Australian skull are large and, as a rule, widely splayed. They have been recorded below (Table LXIII) as moderately splayed when the lateral lamina made an angle of 30°-40° with the median sagittal plane, widely splayed when this angle was 40°-50°, and very widely splayed when the angle was greater than 50°.

TABLE LXIII

Laminae pterygoidei:	Complete Series	
	♂	♀
Size: Small - - - - -	—	—
Moderate - - - - -	7%	15%
Large - - - - -	78%	80%
Very large - - - - -	15%	5%
Splaying of lateral laminae:		
Moderate (30°-40°) - - - - -	46%	41%
Great (40°-50°) - - - - -	52%	57%
Very great (> 50°) - - - - -	2%	2%

The lateral lamina was nearly always larger than the medial lamina. Where this was not so (4% of male and 9% of female skulls) the lateral lamina was much smaller than usual, while the medial lamina had not been reduced.

The attached margin of the lateral lamina usually faded away on the sphenoid anterior to the foramen ovale.

TABLE LXIV

					Complete Series	
Laminae pterygoidei:					♂	♀
Lateral > medial	-	-	-	-	96%	92%
Lateral = medial	-	-	-	-	3%	8%
Lateral < medial	-	-	-	-	1%	0.6%

TABLE LXV

					Complete Series	
Pterygospinous bar and spines of Civinini:					♂	♀
Pterygospinous bar (complete):	-	-	-	-	1.5%	1.2%
Bilaterally	-	-	-	-	30%	40%
Right only	-	-	-	-	20%	20%
Left only	-	-	-	-	50%	40%
Anterior and posterior spines of Civinini	-	-	-	-	6%	5%
Bilaterally	-	-	-	-	18%	26%
Right only	-	-	-	-	54%	26%
Left only	-	-	-	-	28%	47%
Anterior spine of Civinini only	-	-	-	-	3%	2%
Bilaterally	-	-	-	-	42%	55%
Right only	-	-	-	-	42%	11%
Left only	-	-	-	-	16%	33%

TABLE LXVI

					Complete Series	
Band and spines of Hyrtl:					♂	♀
Band of Hyrtl (complete)	-	-	-	-	4%	2%
Bilaterally	-	-	-	-	20%	22%
Right only	-	-	-	-	36%	33%
Left only	-	-	-	-	44%	45%
Anterior and posterior spine of Hyrtl	-	-	-	-	4%	4%
Bilaterally	-	-	-	-	12%	29%
Right only	-	-	-	-	32%	29%
Left only	-	-	-	-	56%	42%
Anterior spine of Hyrtl only	-	-	-	-	0.5%	—
Bilaterally	-	-	-	-	—	—
Right only	-	-	-	-	67%	—
Left only	-	-	-	-	33%	—
Posterior spine of Hyrtl only	-	-	-	-	19%	25%
Bilaterally	-	-	-	-	38%	40%
Right only	-	-	-	-	28%	31%
Left only	-	-	-	-	34%	29%

TABLE LXVII

						Complete Series	
Pterygoid fossa						♂	♀
Deep	-	-	-	-	-	32%	21%
Filled above	-	-	-	-	-	34%	35%
Shallow	-	-	-	-	-	34%	44%

TABLE LXVIII

						Complete Series	
Scaphoid fossa:						♂	♀
Absent	-	-	-	-	-	5%	3%
Slight	-	-	-	-	-	16%	19%
Small	-	-	-	-	-	56%	57%
Moderate	-	-	-	-	-	23%	21%

Some development of the spines of Civinini or Hyrtl was found in 37% of the male and 39% of the female crania; Civinini's spines or band occurring in 10% of the male and 8% of the female skulls, while in the remainder there were anterior or posterior spines of Hyrtl. Details are recorded in Tables LXV and LXVI.

Where there was a complete pterygospinous bar it passed medial to the foramen ovale in half the cases, and over the middle of the foramen in the other half.

Three types of pterygoid fossa are found in Australian skulls. It may be deeply excavated, so that the apex of the fossa extends up to the level of the infratemporal surface of the sphenoid. The apex may be filled with a mass of bone extending for about 5 mm. below the infratemporal surface, the fossa being deeply excavated below this, or the whole fossa may be shallow. In Table LXVII the first type has been called "deep," the second "filled above," and the third "shallow." In two male and one female skull the pterygoid fossa was not developed, and in these cases the pterygoid laminae were greatly reduced.

A distinct scaphoid fossa could usually be made out to the lateral side of the medial lamina. Its development is summarized in Table LXVIII.

(22) *The Jugular Foramen* (Number of skulls, 657 ♂, 501 ♀).

The equality or otherwise of the jugular foramina has been recorded, and the results are given below.

TABLE LXIX

						Complete Series	
Jugular foramen:						♂	♀
Right > left	-	-	-	-	-	82%	82%
Right = left	-	-	-	-	-	7%	6%
Right < left	-	-	-	-	-	11%	12%

(23) *The Tympanic* (Number of skulls, 657 ♂, 500 ♀).

Martin (p. 889) describes four forms which may be taken by the bony borders of the porus acousticus externus. They are:

Type 1 A circle.

Type 2 An ellipse with its long diameter in an antero-posterior direction.

Type 3 An ellipse with its long diameter directed obliquely from behind below to in front above.

Type 4 An ellipse with a vertical greater diameter.

The occurrence of these various forms of porus acousticus externus is given in Table LXX.

TABLE LXX

Form of porus acousticus externus:	Complete Series	
	♂	♀
Type 1 - - - - -	2%	5%
Type 2 - - - - -	0.5%	--
Type 3 - - - - -	81%	78%
Type 4 - - - - -	17%	17%

Hrdlicka (13) has summarized the present knowledge of aural exostoses in his monograph on the subject. In the present series of skulls they were observed in 15% of the male and 5% of the female specimens. The positions in which they occurred are shown in Table LXXI.

The cause of ear exostoses is unknown. They usually arise from what were the free upper ends of the tympanic ring, but may occasionally arise from the squamous portion of the external auditory meatus, as was the case in one female Australian, in which one exostosis was present in the superior wall of the right meatus.

TABLE LXXI

Aural exostoses:	Complete Series	
	♂	♀
Present in - - - - -	15%	5%
Of these: On anterior and posterior walls - - -	13%	4%
Bilaterally - - -	74%	100%
On right only - -	9%	--
On left only - -	17%	--
On posterior walls only -	83%	78%
Bilaterally - - -	81%	78%
On right only - -	7%	17%
On left only - -	12%	5%
On anterior walls only -	4%	13%
Bilaterally - - -	75%	66%
On right only - -	25%	--
On left only - -	--	33%

Hrdlicka notes the part played by a "hereditary influence," and this factor probably explains the occurrence of aural exostoses in eleven out of 25 skulls (presumably of one tribe) from Barmah, Victoria.

The tympanic bone, where it forms the lower boundary of the external acoustic porus, is usually thick in Australian skulls. Viewed from *norma lateralis* the floor of the external acoustic meatus may appear angular, when the anterior and posterior walls meet to form a ridge which is the lateral prolongation of the *vagina processus styloidei*. In the absence of this lateral ridge the floor appears to pass gently from the mastoid process to the postglenoid process of the zygomatic process of the temporal bone, and it may be flat or rounded. Table LXXII shows the occurrence of these conditions.

TABLE LXXII

Tympanic bone, at porus acousticus externus:							Complete Series	
							♂	♀
Size: Thin	-	-	-	-	-	-	10%	11%
Moderately heavy	-	-	-	-	-	-	78%	71%
Massive	-	-	-	-	-	-	12%	18%
Shape: Rounded	-	-	-	-	-	-	38%	48%
Flat	-	-	-	-	-	-	35%	15%
Angular	-	-	-	-	-	-	27%	37%

The development of the ridge known as the *vagina processus styloidei* is very variable, and it is not easy to record concisely the various conditions found. I have here considered this rough ridge as consisting of three parts; the *vagina processus styloidei* proper, a lateral prolongation of this bony spine, and its medial

TABLE LXXIII

Vagina processus styloidei and its prolongations:						Complete Series	
						♂	♀
Vagina processus styloidei proper	-	-	-	-	-	100%	100%
Size: Very small	-	-	-	-	-	3%	6%
Small	-	-	-	-	-	46%	50%
Moderate	-	-	-	-	-	43%	38%
Large	-	-	-	-	-	8%	6%
Lateral prolongation	-	-	-	-	-	29%	40%
Size: Very small	-	-	-	-	-	43%	47%
Small	-	-	-	-	-	52%	50%
Moderate	-	-	-	-	-	5%	3%
Medial prolongation	-	-	-	-	-	90%	88%
Size: Very small	-	-	-	-	-	21%	27%
Small	-	-	-	-	-	59%	62%
Moderate	-	-	-	-	-	19%	11%
Large	-	-	-	-	-	1%	0.5%

prolongation. In some cases there was a well developed spine at the inner end of this medial ridge; its occurrence and size is indicated in Table LXXIV.

TABLE LXXIV

Spine at medial end of medial prolongation:							Complete Series	
							♂	♀
Present in	-	-	-	-	-	-	43%	46%
Size: Very small	-	-	-	-	-	-	29%	32%
Small	-	-	-	-	-	-	52%	60%
Moderate	-	-	-	-	-	-	19%	8%

A suprameatal spine is present in the majority of Australian skulls; its development is shown in Table LXXV.

TABLE LXXV

Suprameatal spine Development:							Complete Series	
							♂	♀
Absent	-	-	-	-	-	-	6%	15%
Trace only	-	-	-	-	-	-	12%	23%
Distinct	-	-	-	-	-	-	82%	62%

(24) *The Foramen of Huschke* (Number of skulls, 663 ♂, 503 ♀).

This foramen was rarely present in these Australian crania, and when it did occur it was usually very small. Some traces were present in 5% of the male and 7% of the female skulls. In the table below it has been described as large when the greatest diameter was 5 mm. or over.

TABLE LXXVI

Foramen of Huschke:							Complete Series	
							♂	♀
Present	-	-	-	-	-	-	5%	7%
Bilaterally	-	-	-	-	-	-	58%	55%
Size: Small	-	-	-	-	-	-	44%	28%
Moderate	-	-	-	-	-	-	44%	72%
Large	-	-	-	-	-	-	12%	—
On right only	-	-	-	-	-	-	26%	24%
Size: Small	-	-	-	-	-	-	37%	25%
Moderate	-	-	-	-	-	-	63%	75%
Large	-	-	-	-	-	-	—	—
On left only	-	-	-	-	-	-	16%	21%
Size: Small	-	-	-	-	-	-	—	15%
Moderate	-	-	-	-	-	-	100%	57%
Large	-	-	-	-	-	-	—	28%

(25) *The Styloid Process* (Number of skulls, 662 ♂, 502 ♀).

A styloid process was present on one or both sides of 77% of the male and 66% of the female skulls.

TABLE LXXVII

Styloid process:							Complete Series	
							♂	♀
Present	-	-	-	-	-	-	77%	66%
Bilaterally	-	-	-	-	-	-	80%	80%
On right only	-	-	-	-	-	-	9%	11%
On left only	-	-	-	-	-	-	11%	9%

When present the process was often quite small, and the large long styloid processes characteristic of European skulls were rarely seen. When the styloid process was large it was usually of a massive build.

TABLE LXXVIII

Styloid process:							Complete Series	
							♂	♀
Size: Very small	-	-	-	-	-	-	3%	7%
Small	-	-	-	-	-	-	36%	45%
Moderate	-	-	-	-	-	-	28%	30%
Long and fine	-	-	-	-	-	-	2%	1%
Massive and short	-	-	-	-	-	-	4%	3%
Massive and moderate length	-	-	-	-	-	-	9%	7%
Massive and long	-	-	-	-	-	-	18%	7%

TABLE LXXIX

Condylod fossa:							Complete Series	
							♂	♀
Present	-	-	-	-	-	-	71%	70%
Bilaterally	-	-	-	-	-	-	72%	69%
Size: Very small	-	-	-	-	-	-	10%	16%
Small	-	-	-	-	-	-	51%	47%
Moderate	-	-	-	-	-	-	35%	35%
Large	-	-	-	-	-	-	4%	2%
Right > left	-	-	-	-	-	-	20%	28%
Right < left	-	-	-	-	-	-	14%	14%
On right only	-	-	-	-	-	-	16%	20%
Size: Very small	-	-	-	-	-	-	14%	31%
Small	-	-	-	-	-	-	59%	57%
Moderate	-	-	-	-	-	-	26%	12%
Large	-	-	-	-	-	-	1.5%	—
On left only	-	-	-	-	-	-	12%	11%
Size: Very small	-	-	-	-	-	-	29%	30%
Small	-	-	-	-	-	-	53%	60%
Moderate	-	-	-	-	-	-	16%	10%
Large	-	-	-	-	-	-	2%	—

(26) *The Posterior Condylod Foramen* (Number of skulls, 616 ♂, 473 ♀).

The occurrence of the posterior condylod foramen and the condylod fossa is quite independent. Both were present in 20% of the skulls (in both sexes), and both absent in 19% of male and 17% of female specimens. Fossae only were present in 31% of male and 26% of female skulls, and foramina only in 9% of male and 13% of female skulls. All other combinations of the presence of fossa and foramen occurred.

The patency and size of the condylod canal was determined by passing wires of various sizes through it, as described under (18) *Foramen of Vesalius*, above. The occurrence and size of the foramina is set out in Table LXXX.

TABLE LXXX

Posterior condylod foramen:							Complete Series	
							♂	♀
Present	-	-	-	-	-	-	48%	55%
Bilaterally	-	-	-	-	-	-	35%	40%
Size ii	-	-	-	-	-	-	2%	7%
iii	-	-	-	-	-	-	50%	49%
iv	-	-	-	-	-	-	48%	44%
Right > left	-	-	-	-	-	-	36%	39%
Right < left	-	-	-	-	-	-	15%	14%
On right only	-	-	-	-	-	-	37%	39%
Size ii	-	-	-	-	-	-	22%	18%
iii	-	-	-	-	-	-	39%	45%
iv	-	-	-	-	-	-	39%	37%
On left only	-	-	-	-	-	-	28%	21%
Size ii	-	-	-	-	-	-	21%	24%
iii	-	-	-	-	-	-	50%	52%
iv	-	-	-	-	-	-	29%	24%

(27) *The Parietal Foramen* (Number of skulls, 654 ♂, 500 ♀).

Boyd (2) on a small series of skulls found that the Australians differed considerably from Europeans in the frequency of occurrence of the various emissary foramina. The presence and size of the parietal and mastoid foramina was recorded for the skulls of this series, Table LXXXI, using the same methods as described above ((18) *Foramen of Vesalius*). Parietal foramina were present in 63% of the male and 65% of the female skulls. In 3% of the crania (of both sexes) there were two parietal foramina on one or both sides (bilaterally in one male and one female skull), and in three male and four female skulls there was a foramen in the sagittal suture as well as on one or both sides.

(28) *The Mastoid Emissary Foramen* (Number of skulls, 641 ♂, 487 ♀).

This was measured as described above. A mastoid emissary foramen was found in 55% of the male and 44% of the female crania. In eleven male and one female skull there were two foramina on one side.

The occurrence and size of the mastoid foramen is set out in Table LXXXI.

TABLE LXXXI

Parietal foramen and mastoid foramen	Complete Series			
	Parietal foramen		Mastoid foramen	
	♂	♀	♂	♀
Present - - - - -	63%	65%	55%	44%
Bilaterally - - - - -	36%	36%	47%	35%
Size: i - - - - -	3%	9%	1%	3%
ii - - - - -	50%	55%	36%	38%
iii - - - - -	47%	36%	56%	59%
iv - - - - -	-	-	7%	-
Right > left - - - - -	32%	7%	29%	23%
Right < left - - - - -	15%	5%	17%	23%
On right only - - - - -	33%	32%	25%	31%
Size: i - - - - -	8%	11%	4%	9%
ii - - - - -	40%	53%	48%	55%
iii - - - - -	50%	36%	38%	31%
iv - - - - -	2%	-	10%	5%
On left only - - - - -	28%	29%	28%	34%
Size: i - - - - -	13%	13%	6%	11%
ii - - - - -	24%	36%	36%	47%
iii - - - - -	60%	47%	47%	38%
iv - - - - -	3%	4%	11%	4%
In sagittal suture only - - - - -	3%	4%		
Size: ii - - - - -	50%	54%		
iii - - - - -	50%	46%		

DISCUSSION

From the examination detailed above, three fairly definite types of Australian skull emerge: (1) type A, the southern type, from South Australia, Central Australia, Victoria, New South Wales and southern Queensland (*i.e.*, the greater part of the continent); (2) type B, from the coastal areas of the Northern Territory; and (3) type C, from the greater part of Queensland (fig. 12). Intermixture makes the lines of division vague, and this vagueness is increased by the paucity of material from south-western and central Queensland and the more central parts of Northern Territory. Of these, type C is by far the least homogeneous group, type A the most homogeneous.

So few specimens from Western Australia were available for examination that the distribution of the types there cannot be given. One or two skulls from north-west Australia correspond with type B, the rest of those examined were similar to the common type A. A subsequent re examination of the Northern Territory specimens showed that some twenty specimens from Booraloola, on the shores of the Gulf of Carpentaria, correspond with type C rather than type B.

However, the inclusion of these skulls in the Northern Territory series does not materially affect the conclusions reached.

The distinctions between these types of skull have been indicated in the preceding pages. The different contours may be seen at a glance in the diptero-graphs (figs. 1-9).

It was pointed out earlier that in a metrical survey of an extensive series of skulls, Hrdlicka (12) noted differences between the Northern Territory, the Queensland, and the southern Australian skulls. Morant (20), in a more

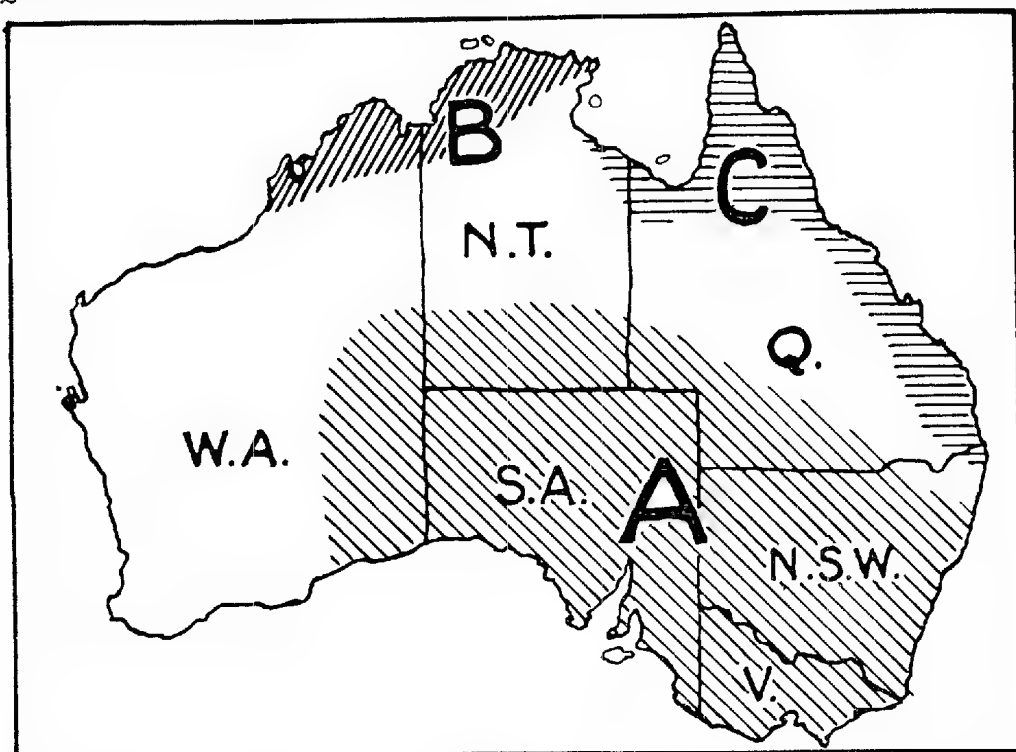


Fig. 12

Map of Australia showing distribution of the different types of skulls:
A, southern type; B, coastal Northern Territory type; and
C, Queensland type. (See text)

extensive statistical analysis of published measurements, came to the conclusion that only two racial types could be distinguished over the whole of Australia. One was confined to the Northern Territory, and differed considerably from the second, which he considered to be spread homogeneously over the whole of Australia, by having a smaller brainbox and slightly differing proportions of height to length and breadth of skull.

Recently Wagner (29) has examined statistically all the published measurements of the crania of the races of Oceania. In Australia he separates the Queensland and Northern Territory groups off from the southern groups, noting that the former resemble each other more than either resembles the southern type. Com-

menting on these findings, he says that "the geographically closest groups show generally the greatest similarity, and the assumption that a foreign northern element has had its influence in a southerly direction, stronger along the east coast than the west, is very plausible." Later, comparing the New Caledonian crania with the Australian, he finds a considerable likeness between them and the Queensland group and says that "... the geographical proximity of Queensland and Melanesian has played a certain rôle and that not one but various racial elements have left their mark on the indigenous population of the northern part of Australia."

By this examination of non-metrical features, it has been possible to differentiate the Queensland (type C) skull quite clearly from those occurring over the rest of the continent, thus confirming Wagner's findings. Morant's differentiation of the Northern Territory (type B) skull is also confirmed. Probably the measurements available to Morant were insufficient to enable him to establish this third racial type (in most of his calculations Morant used the measurements of 18 male Queensland skulls).

It is not possible, by the study of the non-metrical features of the skull alone, to decide the exact significance of these variations. There are three possible causes of the observed differences in skull type. Firstly, isolation for a long period in different kinds of geographical environment. Secondly, the Australian as we know him today may belong to a mixed race, different proportions of the various parent races remaining in different areas of the continent and thus constituting slightly differing racial types. Thirdly, the existing differences may be due to more recent contamination of an originally pure Australian race by the peoples at present living on the borders of the continent, that is by Papuomelanesians in the north-east, and possibly Malays in the north.

The third alternative is merely a later occurrence of the second, for it is fairly obvious that the successive waves of people postulated in the latter must have entered through the northern corridor. In this connection it is of interest to note that a fragment of a fossil human skull found in Aitape, New Guinea, and at present being examined by the writer, approximates fairly closely to the modern southern Australian (type A).

The first cause suggested, i.e., physical differentiation due to long-continued isolation in different types of environment, is not borne out by the geographical distribution of the various types of skull nor by what is known of the habits of the natives.

There has long been an opinion current that the modern Australians are of poly-racial origin, although conclusive evidence has not yet been forthcoming. Turner (27), using the breadth-height relations of the skull as a criterion, suggested that along the southern seaboard of the continent there may have been an inter-mixture (of the Australians) with a people in whose crania the height index was normally less than the breadth index, and he mentioned the Tasmanians as possible ancient inhabitants of southern Australia.

Wunderly (38) has recently summarized the evidence available concerning the origin of the Tasmanians, and considers that it is highly probable that they arrived in Tasmania after having crossed Australia, the remnants having been absorbed by the later wave of early Australians.

The only extensive and detailed physical anthropological studies on the living Australians are those carried out under the auspices of the Board for Anthropological Research of the University of Adelaide. These investigations, summarized in the articles of Campbell, Gray, and Hackett (6), were confined to Central Australia. These writers considered briefly the possibility of the existence of different physical types among the Central Australian aborigines. They came to the conclusion that the population of the area under discussion was homogeneous, and their findings may be summed up as follows: "The consideration of the results of blood grouping alone, or in conjunction with anthropometric data, does not indicate the existence of distinct physical types among the Central Australian tribes."

It is unfortunate that insufficient skulls are available from Central Australia to differentiate them clearly from the southern type A, if any difference exists. Personal observations on living aborigines of central and southern Australia suggest there are some differences, the more northerly peoples being less hairy and less heavily built than their southern neighbours.

Considering now the third possible cause of variation, there has undoubtedly been Papuan admixture in Cape Yorke Peninsula and around the Gulf of Carpentaria, and isolated skulls from these areas show distinctive Papuan features. To what extent differences between the Queensland crania (type C) and those from southern Australia (type A) are due to an extension southward of this Papuan infiltration can only be determined by a detailed study of the living peoples in these areas, such as has recently been undertaken by Birdsell and Tindale, of the Harvard-Adelaide University Expedition.

We may digress for a moment to consider what support for this racial contamination can be obtained from a study of the blood-grouping of the people concerned. Table LXXXII shows the results so far obtained. It must be noted, however, that these results may not be valid for anthropological purposes, for the observers concerned, except Cleland, made no claim to be trained physical anthropologists, and there has been considerable historic second and third generation crossing with Kanakas in the coastal areas of Queensland.

Phillips notes that of the eight group B aborigines which he found, one was a native of Northern Territory, six belonged to tribes from far northern Queensland, and one came from south Queensland.

The gradation of the B factor from Melanesia to southern Australia, if any reliance can be placed on the data, would suggest that the Melanesian infiltration has penetrated a considerable distance. Cleland (7) considers that the intermixtures which introduced the B factor all occurred in the last few centuries, most of them being quite recent. This point again can best be decided by field investigations on the living.

TABLE LXXXII

Author	Locality		Group O (IV)		Group A (II)		Group B (III)		Group AB (I)		Biochemical Index $\frac{A+AB}{B+AB}$
			No.	%	No.	%	No.	%	No.	%	
Cleland and Johnston (8)	South and Central Australia	-	299	39%	407	61%	—	—	—	—	—
Tebbutt and McConnel (24) - - -	New South Wales	-	6	46%	6	46%	—	—	1	8%	7.0
Tebbutt (25)	Queensland (largely southern)	-	99	56%	66	37%	11	6%	1	0.6%	5.6
Lee (17) - -	North Queensland	-	227	60%	120	32%	44	6.4%	6	1.6%	4.2
Phillips (21) -	Queensland	-	39	52%	28	37%	8	11%	—	—	3.5
Heydon and Murphy (11)	Melanesia (New Guinea New Britain New Ireland, etc.) - - -	-	404	54%	202	27%	123	16%	24	3.2%	1.54

We may sum up by saying that on the evidence of this study of the non-metrical cranial characters the Australian aborigine is not a pure homogeneous race, three distinct types occurring in different parts of the continent. They are the long, low, southern skulls with their gently planed occiput and ill-filled temporal fossae (type A); the smaller, higher, narrower Northern Territory type (type B); and the shorter higher Queensland crania with the steep occiputs and fairly well-filled frontal areas and temporal fossae.

It seems probable that the occurrence of these different types is due to at least two factors: (*a*) the prehistoric Australian race was not a pure one, but the result of the fusion of an Australoid with a Tasmanoid stock, and (*b*) there has been a later wave of Papuan, and possible Malay, infiltration into the northern part of the continent.

Klaatsch's belief that the Roth series of skulls on which he worked was characteristic of Australia as a whole, is not supported by the evidence now available. After the study of a larger number of southern skulls than was at that time available to him, Klaatsch could not but have been struck by their differences from the Queensland specimens.

SUMMARY

The present work consists of the examination of 1,182 adult Australian aboriginal skulls for their non-metrical morphological characters. To achieve the uniformity of treatment with other similar racial studies, the plan of examination detailed by Wood Jones (31) has been followed. Two sub-types (B and C), occurring respectively in the coastal Northern Territory and the Queensland areas, have been differentiated from the common southern type A, which occurs over the greater part of Australia.

The findings cannot be profitably discussed here—they are a contribution towards a comparative racial study which can be undertaken when more evidence of a similar nature is available.

It may be of some use to the practical anatomist, as distinct from the physical anthropologist, to give a general summary of the main features of the Australian skull. The southern Australian skull (type A) will be taken as the standard, as types B and C probably represent changes due to contamination with Tasmanian and other later migrant peoples.

In passing, it might be noted that the impression that the average Australian skull is a brutish thing, with tremendous brow ridges, very low forehead, cavernous orbits, very large palate, and a strongly keeled cranial vault, is an erroneous one. It has obviously grown up owing to the frequent descriptions published of outlandish male skulls, with exaggerated racial and sexual characters. Wood Jones' (30) reconstructed normae give a much better idea of the average Australian.

The skull is long, low, and narrow, with a receding forehead on which a median ridge can usually be distinguished and parietal bones which tend to be flattened on either side of the sagittal suture. Small frontal tuberosities are often more evident to the touch than the sight. The parietal tuberosities are small and the posterior parietal region very rarely attains that width and "full blown" appearance characteristic of Tasmanian. The posterior part of the skull slopes back gently behind vertex to lambda owing to the great occipital prolongation of the skull.

The occipital plane of the squama occipitalis frequently projects backwards as a distinct occipital bulge beneath the lambdoid suture. The occipital and nuchal planes of the squama occipitalis usually meet at a fairly small angle, and the line of junction is frequently marked by a well-developed transverse occipital torus. A true external occipital protuberance is very rarely found.

The temporal lines are high and well marked, and the temporal fossae deeply excavated, so that the minimum frontal diameter is small. This latter feature is often accentuated by the lateral projection of the external angular processes of the frontal bone.

The sutural pattern over the cranial vault is simple and sutural bones occur frequently in the lambdoid suture. Emissary foramina occur in the parietal bones in two-thirds of the specimens, and in the mastoid region in about one-half of all skulls.

The mastoid processes are often very small, even in large heavy male skulls, but they vary considerably in size and shape. The tympanic bone is usually thick and heavy, where it forms the lower boundary of the foramen acousticus externus, and has a well-defined ridge corresponding to the vagua processus styloidei. In about 30% of cases the styloid process was not attached, and when present was often quite small.

There is considerable variation in the shape of the porus acousticus externus, but that most commonly found is in the form of an oval with its long diameter directed from behind below to in front above.

The glenoid fossa varies considerably in depth and the zygomatic process of the temporal bone is heavy and curved with an upward convexity. It is also curved out laterally and often forms the widest diameter of the skull.

The basis cranii is long, the palate very large, the basal foramina usually large, and the pterygoid laminae large and well splayed. Well developed foramina of Vesalius are only occasionally found, and accessory spines of Civinini and Hyrtl occur in a considerable number of skulls. The teeth are very large, rarely carious, and usually heavily worn (the degree of wear depending on the age.)

The supraorbital region is usually heavy (at least in male skulls) and nasion is deeply situated in all specimens, being a point of strong contrary flexure. Supra-orbital foramina occur but rarely, a groove or notch usually marking the exit of the supraorbital nerve. Grooves on the frontal bone from nerves or vessels are never encountered.

The orbits are large and sub rectangular in shape, and their infero-lateral border is often not very clearly defined. The nasal bones never rise to a definite high bridge; they are low and saddle-shaped, small in size, and usually constricted in the middle. The narial aperture is large and wide and the lower narial margins usually guttered or smooth. The anterior nasal spine is rarely well developed.

There is a considerable degree of subnasal prognathism, the infraorbital fossae are often very deep and the malar bones fairly massive with everted lower margins and well-developed malar tuberosities.

Plates X and XI show different views of some Australian skulls from which these features may be better appreciated than in diopetrographic drawings.

ACKNOWLEDGMENTS

Professor Wood Jones has been a stimulus and inspiration throughout this work. I also wish to thank Professor F. Goldby, Dr. Charles Fenner, Dr. T. D. Campbell, and Mr. N. B. Tindale, for their help and interest, and the staffs of the various museums visited for their courtesy and unfailing assistance.

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Norma facialis of male South Australian skull
(A 106, S.A.M., Adelaide, from Swanport,
Hindmarsh, S.A.)



Norma facialis of male Northern Territory skull
(A 25531, S.A.M., Adelaide, from Northern Territory)



Norina basalis of male Northern Territory skull
(A 25531, S.A.M., Adelaide, from Northern Territory)



Norina basalis of male South Australian skull
(A 106, S.A.M., Adelaide, from Swanport)

SOME NEMATODES FROM VICTORIAN AND WESTERN AUSTRALIAN MARSUPIALS

By T. HARVEY JOHNSTON and PATRICIA M. MAWSON,
University of Adelaide

Summary

The Victorian material examined was obtained from *Macropus ualabatus* Less. and Garn., *M. ruficollis* Desm., *M. billardieri* Desm., *Potorous tridiactylus* Kerr and *Dasyurus maculatus* Kerr, from Gippsland; and from *Macropus giganteus* Zimm., from the Wimmera. Some of it was collected about forty years ago by Mr. A. S. Le Souef, Director of the Sydney Zoological Gardens; that from *Potorous* was taken by Mr. H. H. Finlayson, Honorary Curator of Mammals, South Australian Museum, Adelaide.

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The Western Australian specimens were collected from *Macropus melanops* Gould, *M. irma* Jourdan, and *Perameles myosura* Wagner, all from the south-western corner of that State.

Amongst the Victorian material we have recognised seventeen species already known elsewhere; a new genus and species of Trichoneminae; and three species, probably new, assigned to genera (*sensu lato*) because of the absence of males. The Western Australian worms belong to three known species. Seventeen of the species mentioned are members of the Strongylidae, two belong to the Trichostrongylidae, two to the Oxyuroidea, and one to the Filarioidea. Types of the new species are deposited in the South Australian Museum.

In the succeeding part of this paper the localities are indicated as G (Gippsland), W (Wimmera), and W.A. (South-western Australia).

Acknowledgment is made of assistance made available through the Commonwealth Research Grant to the University of Adelaide.

PHARYNGOSTRONGYLUS Yorke and Maplestone

P. alpha J. & M. — *Macropus giganteus* (W).

P. beta J. & M. — *M. giganteus* (W).

P. delta J. & M. — *M. billardieri* (G), a new host record.

P. epsilon J. & M. — *M. ualabatus* (G); *M. billardieri* (G), a new host record.

P. zeta J. & M. — *M. ruficollis* (G).

P. theta J. & M. — *M. ruficollis* (G), a new host record.

CLOACINA Linstow

C. magnipapillata J. & M. — *M. giganteus* (W).

BUCCOSTRONGYLUS J. & M.

B. buccalis J. & M. — *M. billardieri* (G); *M. ruficollis* (G); both are new host records.

B. setifer J. & M. — *M. ruficollis* (G), new host record.

B. labiatus J. & M. — *M. ruficollis* (G).

ZONIOLAIMUS Cobb

Z. longispicularis (Wood) — *M. giganteus* (W). Females taken from *M. melanops* (W.A.) appear to belong to this species.

Z. ualabatus J. & M. — *M. ualabatus* (G).

Z. clelandi J. & M. — *M. ualabatus* (G).

Z. communis J. & M. — *M. ruficollis* (G); *M. irma* (WA), a new host record.

Z. uncinatus J. & M. — *M. billardieri* (G), a new host record.

PARAZONIOLAIMUS J. & M.

P. collaris J. & M. — *M. ualabatus* (G).

Potorostrongylus finlaysoni n. gen., n sp.

(Figs. 1-4)

From intestine, *Potorous tridactylus* Kerr, southern Gippsland, coll. H. H. Finlayson.

Male about 10 mm., female about 11 mm. long; cuticle behind head inflated, and body narrowed as far back as level of nerve ring. Head with eight large lips; dorsal and ventral largest, each with conical papilla; four submedian next in size, each with rounded papilla; two laterals shortest, each with rounded papilla. Mouth small; buccal capsule small, 11 μ diameter, 10 μ long, with base 26 μ from tip of lips. Oesophagus about 0.75 mm. long; 1:3-4 of body length; suddenly constricted near posterior end and then widening into a terminal bulb. Nerve ring at 0.28 mm., excretory pore at 0.45 mm. from anterior end. Cervical papillae not observed.

Male—Bursa prominent, longer dorsally than ventrally. Ventral rays short, nearly reaching bursal edge; externo-lateral divergent from laterals, short, stout; laterals almost reaching bursal edge, divergent at tips; externo-dorsal arising separately, terminating some distance from edge of bursa. Dorsal ray bifurcating at about one-third length, each branch extending almost to bursal edge and giving off, soon after its origin, a short lateral stem. Spicules 1.25 mm. long, 1:8 of body length, narrow, with striate alae. Gubernaculum present.

Female—Body tapering gradually to narrow, bluntly pointed tail. Ovejectors 0.33 mm. long; vagina short, wide, 0.3 mm. long; vulva at 1.55 mm. and anus at 0.8 mm. from tip of tail. Eggs 0.08 by 0.04 mm.

Diagnosis of **Potorostrongylus** n. gen. Trichoneminac. Cervical cuticle inflated. Mouth surrounded by eight large lips; short cylindrical buccal capsule; oesophagus cylindrical, ending in constricted region succeeded by bulb. Male—ventral lobes of bursa continuous with each other; ventral rays parallel; externo-lateral divergent from laterals; externo-dorsal arising separately; dorsal ray bifurcating, each branch giving off a lateral ray. Female—tail tapering, bluntly

pointed; vagina a short distance in front of anus. Type *P. finlaysoni* n. sp. from *Potorous tridactylus* Kerr.

The genus resembles *Zoniolaimus* in the shape of the buccal capsule and in some of the lip characters. The main differences lie in the form of the oesophagus, lip papillae, and the general appearance of the bursa.

TRICHOSTRONGYLUS (s.l.) sp.

A sexually-mature female from the duodenum of *Dasyurus maculatus*. Length 3.3 mm., maximum breadth 0.1 mm. Anterior end rounded, with three shallow lips; buccal capsule absent; oesophagus 0.7 mm., 1:4.7 of body length. Vulva 0.6 mm. and anus 0.25 mm. from posterior end. Tail tapering to blunt point. Eggs 0.03 by .045 mm.

TRICHOSTRONGYLUS (s.l.) sp.

(Fig. 5)

An immature worm from the duodenum of *Dasyurus maculatus*. Length 4.8 mm., maximum breadth 0.15 mm. Anterior end a truncate cone, with six small conical papillae and small, strongly cuticularized mouth. Oesophagus 1 mm. long. Tail 0.1 mm. long, narrowing suddenly behind anal region to a sharp point. The characters of the head and oesophagus suggest a young filarial worm, but the form of the tail and the habitat do not support such a view.

DIPETALONEMA ROEMERI (Linstow)

Found in *Macropus giganteus*, Wimmera district.

SUBULURA PERAMELIS Baylis

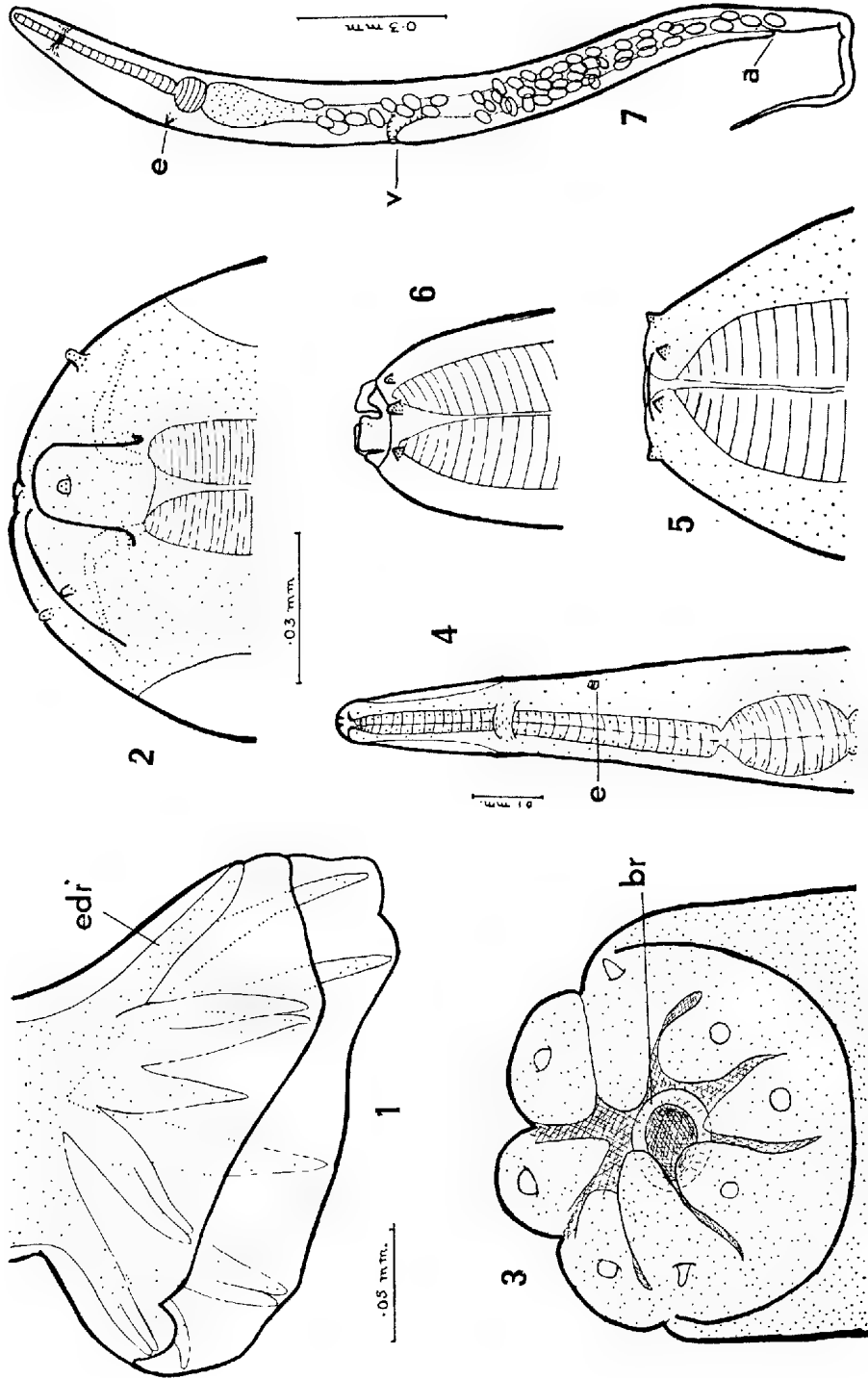
Specimens from a Western Australian bandicoot, *Perameles myosura*, agreed with the original account, except that the lips were slightly longer and the buccal capsule a little deeper.

Oxyuris (s.l.) **potoroo** n. sp.

(Figs. 6-7)

Females from intestine of *Potorous tridactylus*, southern Gippsland, coll. H. H. Finlayson. Length about 2 mm.; maximum breadth, 0.12 mm. Head with three large lips alternating with three smaller; a pair of lateral and two pairs of smaller submedian papillae arranged in a ring just behind base of lips. Buccal capsule absent. Oesophagus 0.4 mm. long, narrow, with terminal bulb .08 mm. wide and .07 mm. long. Nerve ring .01 mm. and excretory pore at 0.36 mm. from anterior end of worm. Anterior part of intestine wider than remainder. Long tail tapering to become threadlike. Anus at 0.5 mm. from tip of tail. Vulva at 0.8-0.9 mm. from head end; i.e., at 1:2.3-2.6 of body length. Eggs 45-50 μ by 20-25 μ .

In the absence of males, the species cannot be assigned more definitely to any Oxyurid genus. It differs from any species hitherto described from marsupials in the absence of a buccal capsule and of cervical inflation, as well as in the arrangement of the lips. The specific name is the aboriginal name for the small rat kangaroo.



Figs. 1-4—*Potorostromyulus fulaysoni*: 1, bursa; 2, head; 3, head, anterior; 4, oesophagus.

Fig. 5—*Trichostromyulus* (s.l.) sp., head. Figs. 6-7—*Oxyuris* (s.l.) *potoroo*: 6, head; 7, entire worm.

Figs. 2, 3, 5 and 6 drawn to same scale. a, anus; br, buccal ring; e, excretory pore; edr, externo-dorsal ray; v, vulva.

THE CRANIAL OSTEOLOGY OF CERTAIN TUBINARES

By H. T. CONDON, South Australian Museum

Summary

While the general osteology of the Tubinares (Procellariiformes) has claimed much attention, there is rather a lack of information regarding the characters of many Australian species, and little data regarding variations due to sex, age or other causes.

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By H. T. CONDON, South Australian Museum

[Read 12 October 1939]

While the general osteology of the Tubinares (Procellariiformes) has claimed much attention, there is rather a lack of information regarding the characters of many Australian species, and little data regarding variations due to sex, age or other causes.

The material described herein is chiefly from South Australia, and is now contained in the Museum collection. The nucleus of the collection was formed by the late Dr. A. M. Morgan, Honorary Curator of Ornithology to the Museum from 1922-34, and since that time it has been the policy of the Museum to retain the crania and other bones of specimens unfit for preservation as cabinet skins.

The general features of the Tubinarine skull have been described by Pycraft (8) in some detail. Many of its characters are distinctive but not unique

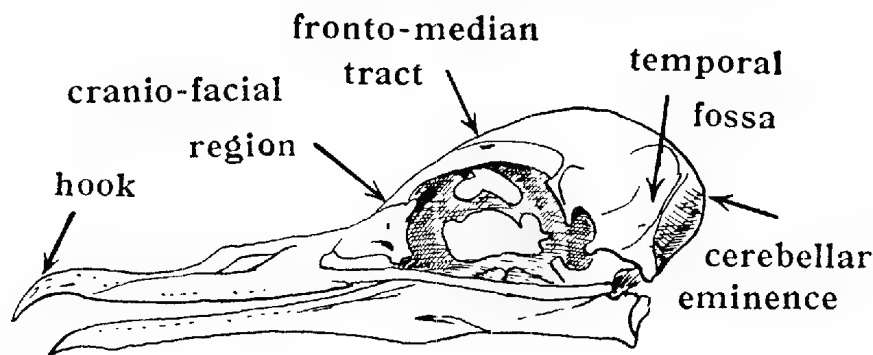


Fig. 1

Skull of *Puffinus tenuirostris*, nat. size, sub-adult, showing regions most affected during growth in Tubinares generally

to the order; in fact, the skull of certain smaller species might easily be confused by the uninitiated with those of Penguins (*Eudyptula*, etc.). Probably the most characteristic features are (a) the large supra-orbital glandular depressions, (b) the large mandibles (with the upper hooked), (c) the "cleft" (schizognathous) palate, with large vomer, (d) the holorhinal nasal bones, i.e., not cleft beyond the ends of the premaxillae, and (e) the angular appearance of the braincase, due to the extensive and often deep muscular impressions of the hinder end.

The outline of the supra-occipital region at once separates the family Diomedidae from all others (see fig. 2 A). The size and shape of the pterygoids readily distinguish some species of Procellariidae, while in other genera they are very uniform. Basipterygoid facets on the basisphenoidal rostrum which articulate with the pterygoids occur in many species (absent in Diomedidae),

and in the smallest forms they may be very minute structures. The lacrimal varies greatly in the different species; the longer axis may be vertical or horizontal, while in certain Procellariidae one or other of the wings of the free bifid end may be enlarged and serves to distinguish the genus or species. In certain genera also, the lacrimal becomes fused with the frontals, nasals, and ethmoidal wing (antorbital plate); in others it remains free.

The vomer is large in all species, with a ventral keel, often decurved anteriorly or with a long spine. The relationship of the quadrate to the surrounding tympanic structures, as pointed out by Lowe (6) is of outstanding significance and provides a means of readily grouping the various genera. Lowe's classification is as follows, but only members of his second family are dealt with herein.

OCEANITIDAE, including *Oceanites*, *Pelagodroma*, *Ptergetta*, *Garrodia*.

PROCELLARIIDAE, including *Pelecanoides*, *Puffinus*, *Pterodroma*, *Daption*, *Thalassoica*, *Priocella*, *Procellaria*, *Pagodroma*, *Macronectes*, *Diomedea*, *Phoebastria*.

In the Oceanitidae (fig. 2 C) the aperture of the upper tympanic recess (ty) is between the facets (i) of the opisthotic and squamosal, whereas in the Procellariidae (fig. 2 D) (with sub-families Procellariinae and Diomedinae) it is outside "the line of the two quadrate facets, which are, moreover, joined by a solid bridge of bone."

The character of the basitemporal plate is often useful; it may be smooth, ridged, or with papillae or mammillary processes (as in *Macronectes*). The Eustachian canal may be open or closed by a downward prolongation from the inferior posterior wall of the orbit (alisphenoid).

The relationship of the supra-orbital glandular depressions to the width of the intervening tract which separates them, seems to be almost worthless from a classificatory point of view, although Pycraft employed it rather extensively; this may have been an error due to the limited material at his disposal.

Unlike the usual condition in the mammalian skull the rapid ossification of the skull in all birds, except the Dromaeognathous types and the Penguins, soon obliterates the sutures between the various bones so that it is a difficult matter to determine the age of an individual by this means. A consideration of the thickness of the frontal bones and the cerebellar region of the Tubinares is useful but not decisive. In the smaller forms the latter region is relatively more prominent in the young stages, when the transverse ridges corresponding to the underlying sulci of the cerebellum are easily distinguishable. In young birds the antorbital plate is always incomplete, varying in degree according to the genus, but in some (e.g., *Pterodroma*, *Daption*, etc.) it becomes complete in the adult. The relative size of the jaws to the rest of the cranium is often a guide, the hook being weaker in young birds, and the shape of the region of the cranio-facial junction varying with age.

Detailed comparisons of a series of skins and skeletons have shown that the majority of Tubinares found washed ashore after gales or flights of migration are young or immature birds, and consequently much of the Museum material obtained in this way is of this class. In the past, this fact has been generally overlooked, and in conjunction with erroneously-sexed examples, has been responsible for many worthless sub-species and even monotypic genera. In this connection

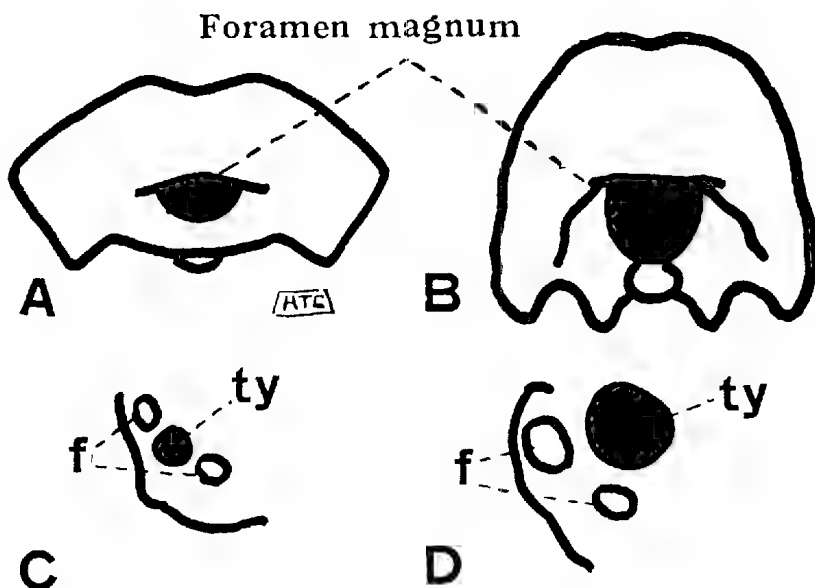


Fig. 2

A, occipital region of *Diomedea*; B, ditto *Macronectes*, diagrammatic; C, quadrato-tympanic region, diagrammatic, of *Oceanites*; D, ditto, *Diomedea*; f, facets for articulation of quadrate; ty, entrance to upper tympanic recess.

the writer has examined the gonads of a score of immature specimens in the flesh and feels that it is often impossible to tell the sex correctly by macroscopic examination only.

KEY TO THE CRANIUM OF GENERA AND SPECIES OF SOUTH AUSTRALIAN TUBINARIES

(Excluding the Prions, Storm Petrels and Diving Petrels)

- I. Dorsal border of supra occipital region slightly curved, basipterygoid facets absent DIOMEDEIDAE
 1. Fronto-median tract in form of a ridge, dentary with wide external groove *Phoebastria*
 2. Fronto-median tract of variable width, dentary of lower mandible without external groove *Diomedea*
 - (1) Size large (above 200 mm.):
 - a. mandibles relatively long, heavy, culmen greatly widened from above *D. exulans*
 - b. mandibles relatively shorter, light, culmen narrow *D. cauta*
 - (2) Size small (less than 200 mm.):
 - a. tomium of maxilla almost straight, base of culmen not thickened as a dome *D. chlororhyncha*

- h. tomium of maxilla strongly convex, base of culmen thickened as a dome *D. melanophris*, *D. chrysostoma*
- II. Dorsal border of supra-occipital region strongly arched, basipterygoid facets present PROCELLARIIDAE
1. Size large (above 140 mm.) *Macronectes*
2. Size smaller (above 70 mm.):
- (1) anterior portion of palate with bony roof extending to the tip of the jaw *Puffinus*
- a. pterygoids from beneath angular and widened anteriorly, hook of pre-maxilla weak.
- (a) upper mandible slender, about $4\frac{1}{2}$ times as long as greatest width at anterior nares *P. gavia huttoni*
- (b) mandibles widened at base, $3\frac{1}{2}$ times as long as greatest width at anterior nares *P. tenuirostris*
- b. pterygoids from beneath apparently "smooth," curved and widened anteriorly, pre-maxilla strongly hooked *P. carnicipes*
- (2) anterior portion of palate without bony reef but with a large vacuity extending from the tip of the jaw to the maxillo-palatines.
- a. upper mandible greatly widened for more than $\frac{3}{4}$ of its length, hook weak *Daption*
- b. upper mandible not widened for more than $\frac{3}{4}$ of its length, hook strong *Pterodroma*
Priocella
Thalassoica

Order TUBINARES (Procellariiformes)

Family DIOMEDEIDAE

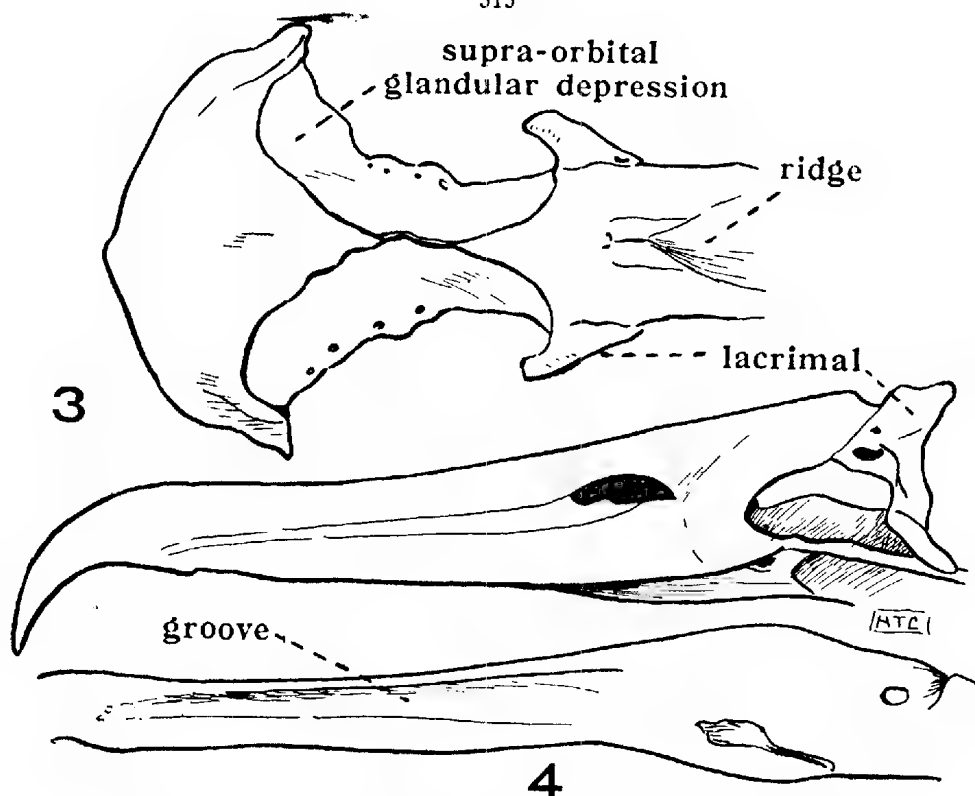
PHOEBETRIA FUSCA (Hilsenborg) — SOOTY ALBATROSS

As far as known, examples of this species have never been found on Australian beaches, reports of dark albatrosses probably referring to the Giant Petrel. One damaged cranium, of unknown origin and sex, has the characteristic ridge separating the supra-orbital glands and the deep and wide external lateral groove on the dentary of the lower mandible. In other features, especially the shape of the mandibles, it resembles closely the skull of *Diomedea chlororhyncha*; but the base of the culmen is raised in the form of a ridge near the cranio-facial junction (cf. figs. 3-4).

Pycraft (8) separated the genus on the fact that the supra-orbital glandular depressions were separated by a sharp ridge only. This feature appears to be characteristic of the genus as several of the crania in the skins of this species, as well as of *P. palpebrata*, have this ridge. In other genera the glandular depressions are separated by a ridge or narrow tract of variable width.

The pterygoid bones are similar in form to those of small *Diomedea* spp, but correspondingly more slender. As in other genera the antorbital wall is very incomplete, and the ethmoidal wings do not meet with the lacrimals.

No.	Total Length	Culmen (Exp.)	Fronto-median Tract
B11380	175 mm.	120	0



Figs. 3-4

Fig. 3 *Phoebastria* sp., fronto-parietal region of cranium, nat. size;

Fig. 4 ditto, mandibles, nat. size

DIOMEDEA EXULANS CHIONOPTERA (Salvin) — SNOWY ALBATROSS⁽¹⁾

Six crania from beach gathered specimens have been examined, representing several stages of immaturity, as follows:

No.	Collector	Locality	Date	Exposed Culmen	Total Length	Fronto-median Tract
11179	A. M. Morgan	S. Aust.	—	140	214	5
17975	H. T. Condon	Younghusband Penin, S.A.	17/8/35	150	233	6
7465	—	S. Aust.	—	158	247	7
11377	—	"	—	165	255	7
11376	—	"	—	170	264	6
11378	—	"	—	172	269	8

Apart from a relatively shorter culmen in the smaller and younger examples the crania examined were remarkably uniform in structure, although the region of the cranio-facial junction is relatively wider in older examples. Forbes (3) figured the vomer of *D. exulans*, while Pycraft has indicated the main features in his illustration of the dorsal and ventral views. Lowe (6), also, has figured the quadrato-tympanic region of the skull (fig. 2 C and fig. 2 D) to demonstrate the condition obtaining in all Diomedidae and Procellariidae.

(1) See Falla (2).

DIOMEDEA CAUTA CAUTA Gould — WHITE-CAPPED ALBATROSS

Although breeding in Eastern Australia, this is a rare species in South Australia. A few examples have been discovered, mainly in the South-East and the Encounter Bay district.

The skull of *D. cauta* approaches that of *D. exulans* in the character of the deeply excavated nasal fossae of the supra-orbital glands. Unlike those of the smaller species of the genus the external borders of these fossae are strongly raised posteriorly from a prolongation of the post-orbital processes, and approach very closely to the free limbs of the lacrimals in the adult. In conjunction with its size, the skull of this species is readily recognised by the long, narrow upper jaw, and the basally thickened and broadened culmen. From a lateral aspect the upper jaw is very deep at the base (figs. 6-7).

Three crania in the Museum collection as follows:

No.	Collector	Locality	Date	Exposed Culmen	Total Length	Fronto-median Tract
5297	A. M. Morgan	Goolwa, S.A.	-/4/1924	130	206	11
5293	J. B. Cleland	Encounter B., S.A.	-/1/1925	130	202	9
6342	"	"	-/1/1926	124	200	8

DIOMEDEA CHLORORHYNCHA Gmelin — YELLOW-NOSED ALBATROSS

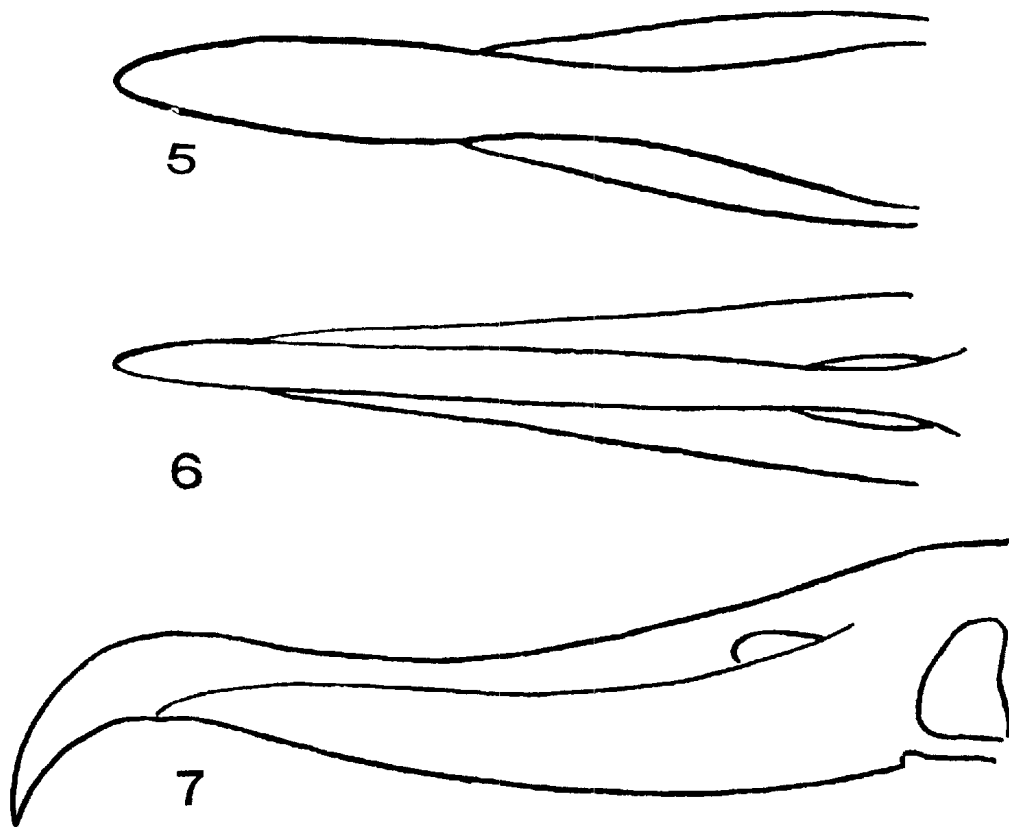
From the reports of observers this appears to be a common species in South Australia during the winter months. In 1935 there was a large visitation of the species (Condon (1)), during that year twelve crania being obtained, as listed hereunder:

Crania of *Diomedea chlororhyncha*

No.	Collector	Locality	Date	Exposed Culmen	Total Length	Fronto-median Tract
17979	H. T. Condon	Sellick's B., S.A.	17/8/35	120	190	9
18017	B. C. Cotton	Yorke Penin. S.A.	/9/35	110	180	7
17866	H. C. Collyer	Brighton, S.A.	24/6/35	115	182	8
17980	D. W. Brummitt	Younghusband Penin., S.A.	17/8/35	118	183	8
*18067	H. T. Condon	"	"	112	180	9
18068	"	"	"	116	183	7
17918	"	Pt. Gawler, S.A.	21/7/35	114	178	6
17935	"	Sellick's B., S.A.	4/8/35	112	179	6
*17933	"	"	"	115	177	6
*17934	"	"	"	107	175	5
17936	W. G. Torr	Brighton, S.A.	-/7/35	113	180	6
17957	H. C. Collyer	"	"	110	175	5

The crania are of birds of various stages of immaturity but all except three (*) had a yellow culmen, although the unguis was uncoloured. Except for slight differences in total length and the width of the fronto-median tract all specimens are extremely uniform. The average total length is less than that of *D. melanophris*.

The maxillae are different in character but otherwise the various bones of the skull are indistinguishable from those of *D. melanophris* and *D. chrysostoma*. Indeed, structurally, these three species are very closely allied, there being no obvious differences in the pterygoids, lacrimal, vomer or other bones (including the sternum). A specific determination is, in our present state of knowledge, reliant on examination of the soft parts, including bill and plumage.



Figs. 5-7

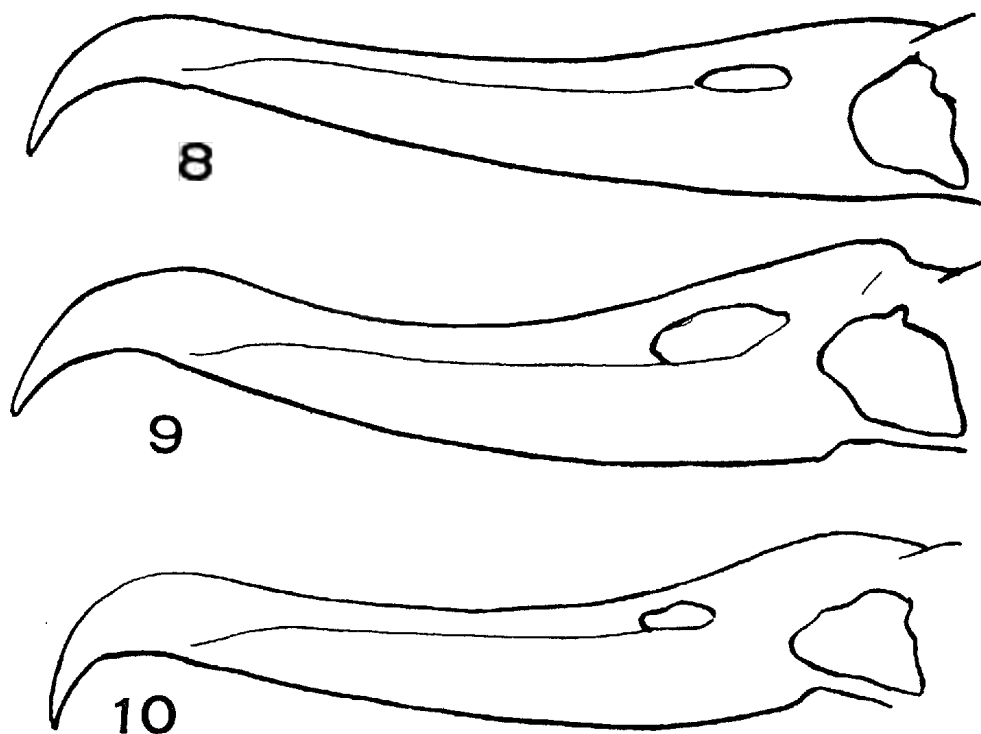
Fig. 5, *Diomedea exulans*, imm., upper mandible from above;
Fig. 6, *D. cauta*, upper mandible from above; Fig. 7, ditto, lateral view
All nat. size

DIOMEDEA MELANOPHRIS Temminck — BLACK-BROWED ALBATROSS
and

DIOMEDEA CHRYSOSTOMA Forster — GREY-HEADED ALBATROSS

Both of these species, as a rule, occur together with the Yellow-nosed Albatross, but apparently in lesser numbers. There are five crania of *D. melanophris* and one of *D. chrysostoma* in the collection. They are all very similar, although that of *D. chrysostoma* is smaller (? juv.) and has the tomium less strongly convex. For certain diagnosis of this species reference must be

made to the colourations and shape of the horny bill. *D. chrysostoma*, in many of its characters, appears to be between *D. melanophris* and *D. chlororhyncha*. The skull of the Black-browed Albatross, however, usually has the base of the culmen raised as a ridge or dome in the adult; this region corresponds to the base of the horny culminicorn, and as such is distinctive from *D. chlororhyncha*.



Figs. 8-10

Fig. 8, *Diomedea chlororhyncha*, sub-adult; Fig. 9, *D. melanophris*, sub-adult;
Fig. 10, *D. chrysostoma*, sub-adult. All nat. size

Crania of Diomedea melanophris

No.	Collector	Locality	Date	Exposed Culmen	Total Length	Fronto-median Tract
11379	—	—	—	107	—	3
17917	H. T. Condon	Pt. Gawler, S.A.	21/7/35	108	178	4
17978	"	Younghusband Penin., S.A.	17/8/35	121	197	6
17955	W. G. Torr	Brighton, S.A.	-/7/35	116	188	5
21992	A. Ey	S.A.	-/-/38	114	180	5

Cranium of Diomedea chrysostoma

No.	Collector	Locality	Date	Exposed Culmen	Total Length	Fronto-median Tract
B22074	—	W.A.	—	104	—	5

Family PROCELLARIIDAE

MACRONECTES GIGANTEUS (Gmelin) — GIANT PETREL

Remains of this species have been recorded from South Australia for almost every month in the year, and they are especially common in the winter time. No difficulty in identification is presented if the horny bill is intact, and it is possible to tell the sex at a glance even in immature birds from the shape of this structure alone (fig. 13 E).

The main features of the skull of the Giant Petrel are well known. The presence of so-called "basi-pterygoid processes" was first emphasized by

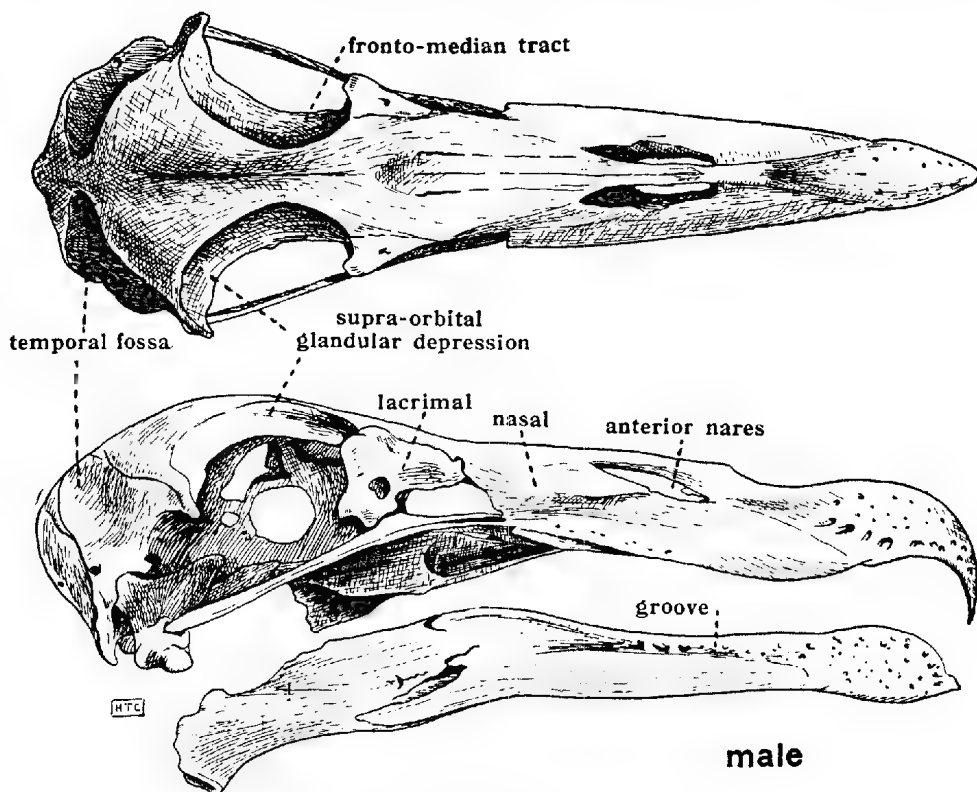


Fig. 11

Skull of *Macronectes giganteus*, male, B 11382

Huxley (4), who from lack of further material was forced to quote their presence in this species as a unique feature in the Procellariidae. Since that time basi-pterygoid facets have been described in other species by Forbes (3), Shufeldt, and others, and the resulting information has been neatly summarised in broad outline by Pycraft (8) in his key to the genera of the world. The descriptions, however, were apparently based on a limited number of specimens in many instances, and differences due to age or sex were not considered.

There are six crania of both sexes of the Giant Petrel in the South Australian Museum. Remarkable individual differences are apparent. After separating the sexes (the mandibles are smaller in females) it is revealed that there is much variation in the width of the fronto-median tract between the nasal glandular depressions (figs. 11-12).

In the appended tables the width of this tract at its narrowest part, together with other measurements, is given for all specimens examined. From the limited amount of material available, the data indicate that differences in the width of this tract are approximately proportional to the length of the culmen and to age, the area being wider in adult birds. Further examples may be needed for confirmation, but should this prove correct, a simple method of telling the age of cabinet skins is indicated.

Crania of Macronectes giganteus (Gmelin)

No.	Collector	Sex	Locality	Date	Exposed Culmen	Fronto-median Tract
B11383	—	♂	—	—	105	9
B11382	T. Batson	♂	Middleton Beh., S.A.	14/10/1915	103	9
B6341	J. B. Cleland	♂	Encounter B., S.A.	—/1/1926	95	2.5
B11381	—	♂	—	—	97	8
B17176	J. B. Cleland	♀	Encounter B., S.A.	—	89 (2)	6.5
B17864	H. C. Collyer	♀	Brighton, S.A.	21/6/1935	83	6.5

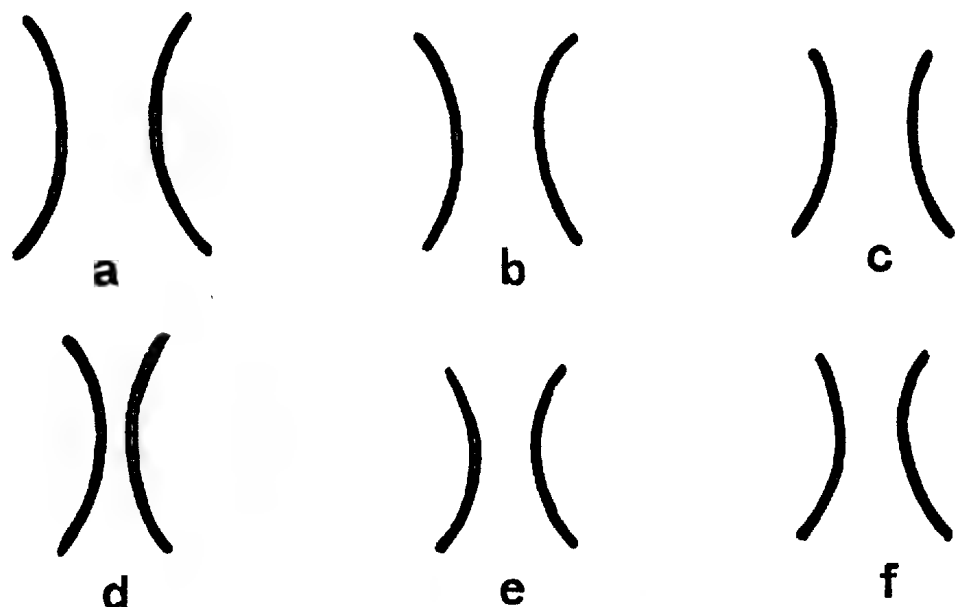


Fig. 12

Variations in form of fronto-median tract in crania of *Macronectes giganteus*:
a-d, males; e-f, females

a, culmen 105, tract 97 (B 11383); b, culmen 103, tract 9 (B 11382); c, culmen 97, tract 8 (B 11381); d, culmen 95, tract 2.5 (B 6341), immature; e, culmen 89, tract 6.5 (B 17176); f, culmen 83, tract 6.5 (B 17864).

(2) Has the limy encrustation at the base of the bill well developed.

Skins of *Macronectes giganteus* (Gmelin)

No.	Collector	Sex	Locality	Date	Wing	Tail	Tarsus	Middle Toe and Claw		Fronto-Exposed median Culmen	Tract	Remarks
B1099	H. Hamilton	♂	MacQuarie Island	1912	50	22	95	150	107	9 (?)	White phase, adult	
B17896	L. Thomas	♂	Normanville, S.A.	8/7/1935	51	18	90	140	105	12	Imm., no limy encrustation at base of bill	
B308	H. Koop	♂	Warooka, S.A.	16/7/1912	54	21	95	140	100	12	" " " "	
B6874	G. Stenning	♂	near Cowell, S.A.	25.7/1926	53	19	95	140	100	15	" " " "	
B4018	J. C. Verco	♂	Henley, S.A.	17.8.1922	51	19	95	140	101	13	" " " "	
B2987	H. C. Collyer	♂	Brighton, S.A.	1/8/1923	52	20	95	140	100	12	" " " "	
B17929	H. T. Condon	♂	Sellick's Beach, S.A.	—/3/1935	54	20	95	140	98	12	" " " "	
B5330	J. Foglia	♂	Pt. Noarlunga, S.A.	—/8/1925	52	19	95	135	97	9	" " " "	
B17879	H. T. Condon	♂	Sellick's Beach, S.A.	25/6/1935	54	19	95	140	96	10	" " " "	
JBC697	J. B. Cleland	♀	Encounter Bay, S.A.	21/1/1924	50	18	90	130	87	12	See text	
B15702	S. McMillan	♀	Glendlg, S.A.	30/7/1932	50	19	85	125	86	10	Imm., no encrustation	
B12357	H. C. Collyer	♀	Brighton, S.A.	11/7/1931	50	19	90	130	85	7	" " " "	
B12558	D. Hersey	♀	Henley, S.A.	12.7/1930	50	19	85	120	84	8	" " " "	
B6886	F. Wood Jones	♀	St. Vincent Gulf	14/8/1926	47	17	85	125	82	11	See text	
B17878	H. T. Condon	♀	Sellick's Beach, S.A.	25/6/1935	50	18	80	120	81	7	Imm., no limy encrustation at base of bill	
B2980	H. Smith	♀	Died in captivity	1/7.1919	45	16	80	125	81	11	See text	
B22020	C. L. Harte	♀	Brighton, S.A.	17/7/1939	52	23	95	137	97	10	Imm., no encrustation	

In order to discover the significance, if any, of such variation, measurements were taken of a series of seventeen skins of both sexes, as in the following table. Most of these were young birds of various ages with shiny brownish-black plumage. The only individuals which appeared to be approaching maturity were the following:

No. 697 (J. B. C. Coll.). Female found by Prof. J. B. Cleland on the beach at Encounter Bay, South Australia, in a dying condition on 21 January 1934. This individual has the limy encrustation at the base of the bill and the light brownish mottled ptilosis of older birds. Details from the attached label are as follows: "iris, very dark brown; bill, pallid horny, whitish, integument between the plates with a pinkish tinge; pharynx, livid whitish; feet, greyish-brown; total length, 30.5 inches; span of outstretched wings, 74.5 inches." Fronto-median tract 12 mm. (the maximum for a female).

No. B6886. Female collected in St. Vincent Gulf by Professor F. Wood Jones on 14 August 1926. There is a slight encrustation at the base of the bill. The plumage is worn and mottled and there are many whitish feathers about the head at the base of the bill. Details are as follows: "iris, very dark brown; bill, very light horn colour tip darker; pharynx, whitish; feet, dark leaden grey; total length, 79 cm.; span of wings, 186 cm.; weight, 7 lbs." Fronto-median tract, 11 mm.

No. B2980. Female captured in 1916 and kept in captivity for three years by Mr. H. Smith. The bird died on 1 July 1919. The limy encrustation at the base of the bill is well marked, and the plumage is very worn, but these features may be due to the unnatural conditions under which the bird lived. The skin exhibits most of the features of an adult. Fronto-median tract, 11 mm.

The Os lacrimo-palatinum (os ucinatum) has generally been quoted as absent in *Macronectes giganteus*. In two crania examined a male (B11381) and a female (B17864) there is a small vestige, about 3 mm. long, present. It projects downwards from the base of the lacrimal near its junction with the wing of the ethmoid, and probably represents the os lacrimo-palatinum of *Puffinus*, *Diomedea* and other genera. Because of its fragility and minuteness the structure is probably lost in the process of maceration in most instances.

PUFFINUS GAVIA HUTTONI Mathews — WHITE-BREASTED (Fluttering) PETREL⁽³⁾

The Fluttering Petrel is one of the lesser known species of *Puffinus* frequenting South Australian seas. As at times it is very numerous (9, 10), being seen in immense flocks, it is rather remarkable that its remains have not, up to the present, been discovered on beaches after stormy weather.

There is in the South Australian Museum collection an incomplete skeleton of this species, in all probability collected in South Australia. The slender bill of the cranium is distinctive.

⁽³⁾ The nomenclature followed herein is that of Serventy (10, 11), who has recently supplied us with further details of occurrence, identification and osteology. The present writer feels, however, that *P. gavia huttoni* may eventually be raised to full specific rank.

Description of Cranium (fig. 14)

Mandibles relatively long and slender, hook of upper weak and slightly decurved, with a few foramina. Anterior nares relatively large and widened; nasals entirely absorbed. Base of upper mandible depressed at the cranio-facial junction, where there is a deep pit. Supra-orbital glandular depressions large, well marked and uniform, and separated by a narrow fronto-median tract. Post-orbital process very thin, large, wing-like, and flat. Parietal region smooth, rounded postero-laterally and somewhat depressed from above; temporal fossae well marked, bounded posteriorly by a prominent crest and extending for some distance on to the prominent "cerebellar eminence"; paroccipital processes small. Lacrimal roughly triangular, longer axis horizontal, pierced by two foramina, the larger ventral one pneumatic, and in contact above with the frontal, anteriorly with the nasal, posteriorly with the wing of the ethmoid and inferiorly with the infra-orbital bar which is slightly bent up to meet it. Os lacrimo palatinum well developed, about 3 mm. long and widened at its distal end. A large foramen of irregular shape is in the superior posterior wall of the orbit (orbito-sphenoid); the anterior wall is incompletely formed by the wing of the ethmoid. The inter-orbital septum is perforated by a large sub-circular foramen and the optic foramen, the two running into each other, forming one. Mandibles parallel to the basi-cranial axis. Palatines large and flattened, and slightly below the infra-orbital bar, and the maxillo-palatines are just visible at their anterior ends. The vomer is large, flattened, decurved anteriorly, with a ventral keel which does not extend to the tip. The internal laminae of the palatines are in the form of fairly well developed carinations. Pterygoids widened and flattened anteriorly at their junction with the rostrum (cf. *P. tenuirostris* in form). Basipterygoid facets present near the base of the rostrum; basitemporal plate triangular and relatively smooth with transverse ridge. Eustachian canal closed by a prolongation from the alisphenoid with a wide exit. Lower jaw very weak, anterior symphysis short, tip slightly decurved, perforated by many small foramina along a line on the dentary corresponding to the groove (sulcus) of the ramicorn. Coronoid process of surangular small. Concave articular surfaces for the quadrate large, internal articular process perforated by an elongate pneumatic foramen. Angle of mandible truncated. Other features as in *Puffinus tenuirostris*.

Total length, 76 mm.; culmen, 42 mm.; fronto-median tract, 1.0 mm. Probable length of exposed culmen, 34 mm.

PUFFINUS TENUIROSTRIS (Temminck) — SHORT-TAILED PETREL
and

PUFFINUS CARNEIPES Gould — FLESHY-FOOTED PETREL

Among the large numbers of Mutton Birds discovered on South Australian beaches following their return in November, some examples of the Western Australian Mutton Bird or Fleshy-footed Petrel, *Puffinus carneipes* are not infrequently found among the remains of *P. tenuirostris*.

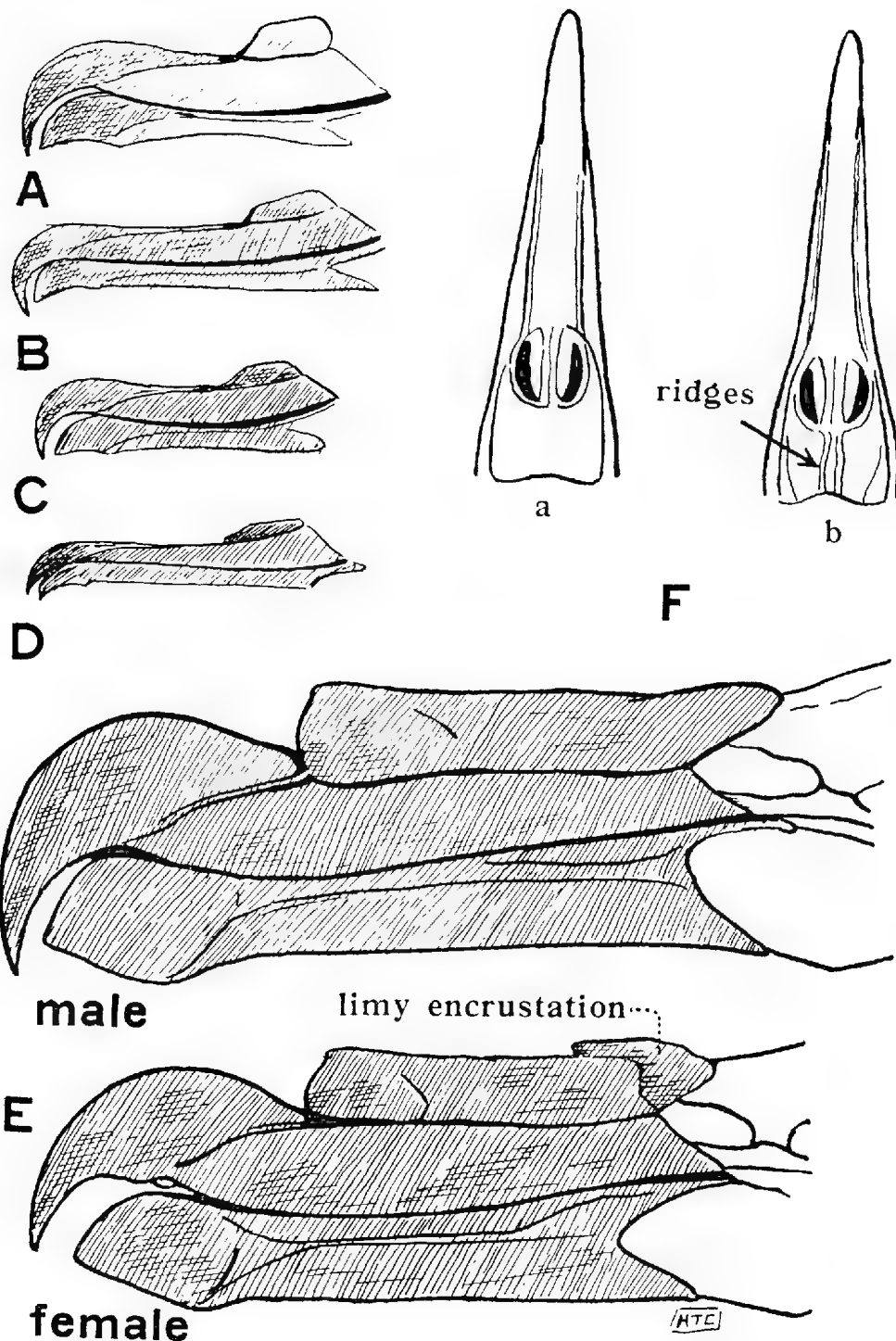
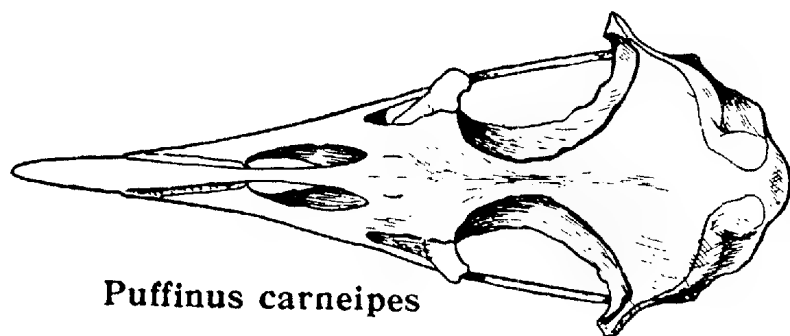
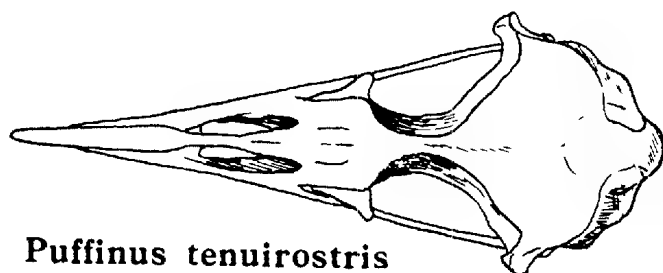


Fig. 13

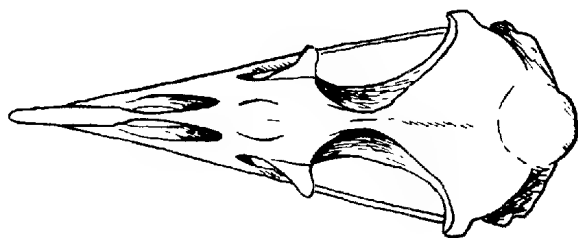
Bills of South Australian Procellariidae: A, *Puffinus caruipex*; B, *P. griseus*; C, *P. tenuirostris*; D, *P. gavia huttoni*; E, *Macronectes giganteus*; all natural size; F, dorsal view of bills of a, adult, b, immature, males of *P. tenuirostris* to show character of naricorn. $\times 2$



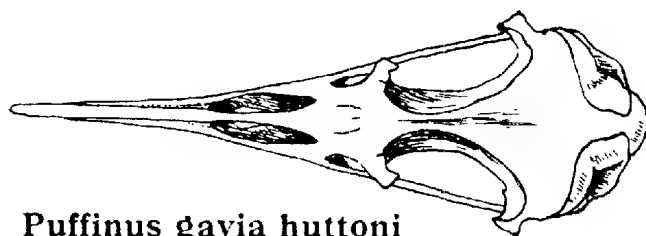
Puffinus carneipes



Puffinus tenuirostris



***Puffinus tenuirostris* juv.**



Puffinus gavia huttoni

HTC

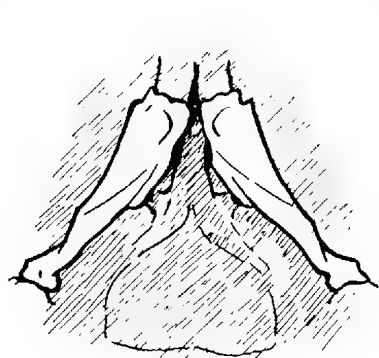
Fig. 14
Crania of South Australian *Puffinus*, from above. Natural size

As with most Tubinares, no difficulty in separating the two species is presented if the horny bill is intact (fig. 13). Not rarely, however, this part has disappeared through exposure, so that by the time the remains are gathered their identity is not readily apparent.

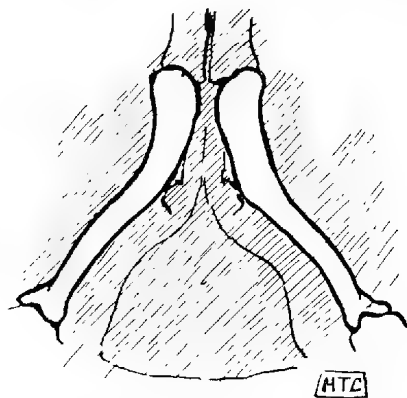
In adults, the skulls can be distinguished by the relatively smaller and shorter mandibles of *Puffinus tenuirostris* (figs. 2, 14), but in juveniles little reliance can be placed on this character. In these cases, the species can be instantly diagnosed on the character of the pterygoids (fig. 15). In *Puffinus tenuirostris* these structures, when viewed from beneath, *in situ*, are greatly widened and flattened anteriorly and of angular appearance, while in *Puffinus carneipes* they are comparatively slender and present a smooth and rounded appearance. Dorso-laterally they are angular in both species.

Crania of *Puffinus tenuirostris* (Temm.)

S.A.M. No.	Collector	Locality	Date	Culmen (°)	T t ¹ Length	
B5304	A. M. Morgan	Robe, S.A.	-/12/1923	44	82	
B5299	"	"	-/12/1924	43	82	
B12408	Miss J. Cleland	Encounter B., S.A.	-/5/1930	42	81	
B11000	A. M. Morgan	S.A.	—	42	80	
B18667	W. B. Hitchcock	Younghusband Penin., S.A.	-/2/1937	42	80	
B5079	—	—	—	34	72	? Juv.



Puffinus tenuirostris



Puffinus carneipes

Fig. 15

Pterygoids, *in situ*, viewed from beneath. Greatly enlarged

Shufeldt (12), in describing what he believed to be an adult of *Puffinus tenuirostris*, notes that the "supra-orbital glandular depressions meet for a short distance in the median line."

None of the skulls examined exhibit this condition, the glandular depression being separated by a wide and flat tract (in B12408 and B5079), a narrow ridge (in B5299) or a deep but narrow groove (in B5304, B11000, and B18667).

(¹) Not to be confused with exposed culmen.

Despite the variability of this region Shufeldt's example, being adult, may belong to some other species.

As with other Petrels, the form of the bill (horny culminicorn) is almost independent of the shape of the premaxillae and maxillae, although in the immature stages it may approximate closely in the form of these structures. Serventy (10) has drawn attention to the remarkable changes produced in the horny external tubular nares of *Puffinus gavia* by contraction of these parts some time after death. In *Puffinus tenuirostris* and, to a lesser degree, *P. carneipes*, this effect is most noticeable in immature birds. In fact, the writer has found that this character forms a useful guide for the separation of skins of young birds and adults. In the adult the structure is thickened and of smooth appearance, while in juveniles it is shrunken in appearance and the integument has one, two, or more longitudinal crinkles or ridges (fig. 13 E).

Crania of *Puffinus carneipes* Gould

S.A.M. No.	Collector	Locality	Date	Total Culmen ()	Total Length	
B18641	H. T. Condon	Reevesby Is., S.A.	-/12/1936	50	93	
B5298	A. M. Morgan	Robe, S.A.	-/12/1924	49	90	
B11394	—	—	—	49	90	
B5296	F. Wood Jones	Coffin's Bay, S.A.	/1/1925	49	89	
B11904	J. B. Cleland	Encounter B., S.A.	-/1/1930	48	90	? Juv.

PUFFINUS GRISEUS (Gmelin) — SOOTY PETREL

Remains of this Mutton Bird which, except for its size is very much like the Short-tailed Petrel (*Puffinus tenuirostris*) were discovered on the beach at Encounter Bay on 22 January 1931 by Professor J. B. Cleland (13), this being the only record from South Australia. All remains of Mutton Birds from South Australia should be re-examined to ascertain if they are of this species (fig. 13 B).

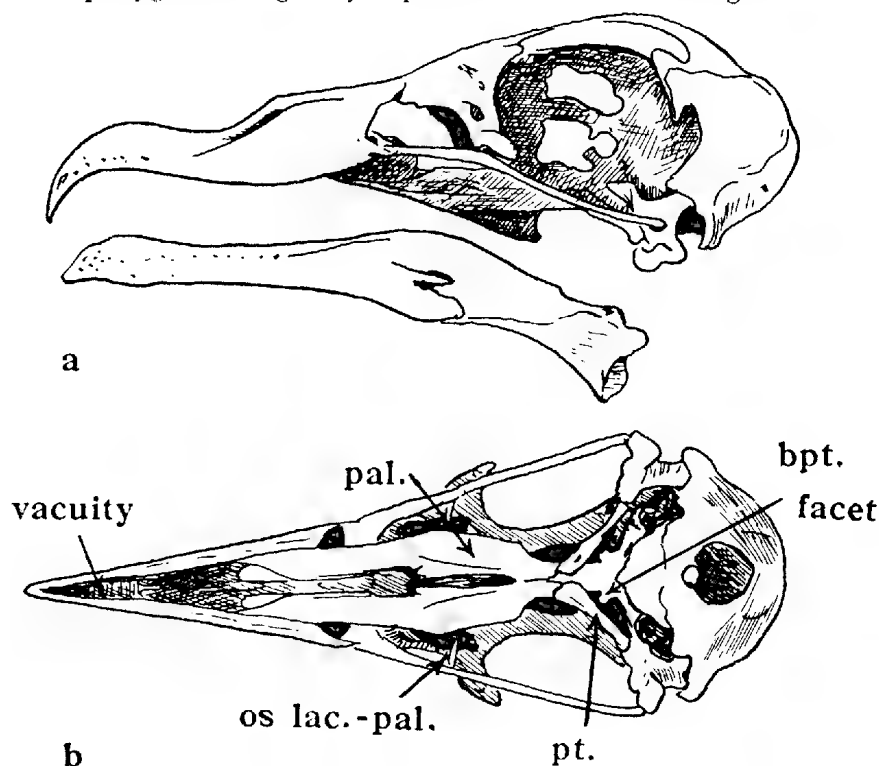
PTERODROMA LESSONI (Garnot) — WHITE-HEADED PETREL

The White-headed Petrel has been recorded from South Australia on five occasions, and all examples are now in the Museum.

At a cursory glance the cranium of *Pterodroma* does not differ greatly from that of certain species of *Puffinus*. Closer examination, however, reveals many differences: the lacrimal is completely fused with the nasal and frontal and ethmoidal wing, while in adults the antorbital wall is complete. The mandibles are comparatively stronger than in *Puffinus*, the upper being strongly hooked. Anteriorly the palate of *Pterodroma* has not a bony roof as in *Puffinus*. The palatines are short and wide and basipterygoid facets are present at the base of the basisphenoidal rostrum. The frontal region also is more prominent, being widened and thickened in *Pterodroma*.

Individual variations in the specimens examined are slight: the supra-orbital fossae are separated by a deep groove wider than the average in *Puffinus*. Comparison between crania of *Pterodroma* from South Australia, and *Thalasseica*

antarctica, and *Priocella antarctica*, collected by the Australasian Antarctic Expedition (1911-1914) and which have also been recorded from South Australian seas, although made on limited material, shows that except for the relatively large size of *Priocella*, the other genera can only be distinguished from *Pterodroma* by the character of the palatines, the outer margins of which are tapered in *Pterodroma* but parallel in *Thalassoica* and *Priocella*. In the last-named the pterygoids are greatly expanded, with "lateral wings."



Pterodroma lessoni

Daption capense

Fig. 16

Skull, *Pterodroma lessoni*: a, lateral view; b, from beneath; pal., palatine; bpt. facet, basiptyergoid facet; pt., pterygoid; vacuity, anterior vacuity of palate; os lac.-pal., os lacrimo-palatinum. Skull of *Daption capense*, from above. All natural size.

Skins of *Pterodroma lessoni*

S.A.M. No.	Collector	Locality	Date
B16849	W. C. Hamilton	Semaphore, S.A.	29/5/1933
B17808	B. C. Cotton	Goolwa, S.A.	13/4/1935
J.B.C. Coll.	J. B. Cleland	Encounter B., S.A.	17/12/1924

Crania of *Pterodroma lessoni*

S.A.M. No.	Collector	Locality	Date	Total Culmen	Total Length
B5265	M. Bonnin	Boatswain Point, S.A.	26/12/1924	49	91
B11905	J. B. Cleland	Encounter B., S.A.	-/1/1930	47	90

Cranium of *Thalassoica antarctica*

S.A.M. No.	Collector	Locality	Date	Total Culmen	Total Length
B1167	D. Mawson	Adelie Land	1912	50	93

PTERODROMA MACROPTERA GOULDI (Hutton) — GREY-FACED PETREL

The only South Australian example, a female, was obtained alive by the late F. R. Zeitz, of the South Australian Museum at Brighton beach, after westerly gales on 19 August 1917. In the skin as it is today the forehead, lores and chin are light in colour, not silvery-grey as given by Hutton in the original description. (Ibis, 1869, p. 351.) Measurements are as follows: Total length, 395 mm.; culmen, 34 mm. (1.3 inches); wing, 315 mm.; tail, 127 mm.; tarsus, 41 mm.

Iris: dark brown; feet and bill, black.

In December 1923 the late Dr. A. M. Morgan found at Robe, South Australia, the decomposed body of a *Pterodroma* which he recorded as *P. macroptera*. Since that time several examples of the related *P. lessoni* have been discovered on beaches, and two crania of this species have been preserved. Comparisons of these with that obtained by Dr. Morgan at Robe reveal no structural differences. It is probable, therefore, that the Robe specimen was not *P. macroptera* but *P. lessoni*, or, alternatively, the two species are osteologically identical. From comparative studies in other genera this latter view does not seem tenable, as some osteological differences are usually apparent in the different species of Procellariidae.

Details of this cranium are as follows:

S.A.M. No.	Collector	Locality	Date	Exposed Culmen	Total Length	Fronto- median Tract
B5300	A. M. Morgan	Robe, S.A.	/12/1923	35	110	2.5

DAPTION CAPENSE (Linne) — CAPE PETREL

There are eleven records of this species in South Australia, as follows:

Locality	Collector	Date	
Goolwa, S.A.	F. W. Andrews	11/10/1865	skin not preserved
South Australia	S. White	-/8/1870	two skins
Cape Borda, S.A.	J. Burke	-/6/1891	two skins (male & female)
Encounter Bay, S.A.	J. Shannon	8/7/1923	male
" " "	J. B. Cleland	16/7/1926	sternum
" " "	Miss J. Cleland	-/9/1930	skeleton

Seacliff, S.A.	E. Ashby	13/10/1926	female
Hallett's Cove, S.A.	H. T. Condon	-/7/1935	sternum and wings
Yorke Peninsula, S.A.	B. C. Cotton	-/9/1935	cranium (juv.)
South-East, S.A.	A. Ey	/11/1939	"
" " "	" "	-/11/1939	" (juv.)

Apart from its brilliant black and white plumage, this species is readily distinguished by the skull (fig. 16), in which the upper jaw is greatly widened for more than three-quarters of its total length and is bent at an angle to the basi-cranial axis. As in *Pterodroma* in the adult the anterior wall of the orbit is completely ossified and the lacrimal is completely fused with the frontal and wing of the ethmoid. In the juvenile examined (B18018), there is a large foramen in the antorbital wall, cf. *Puffinus*, while the lacrimal is not completely fused above. The cerebellar eminence is very prominent in this example and exhibits transverse ridges corresponding to the sulci of the cerebellum. The area separating the supra-orbital glandular depressions is less than in the adult. The anterior vacuity of the palate is wide and extends to the tip of the jaw (as in *Pterodroma*, fig. 16), and basipterygoid facets are present. The os lacrimo-palatium is absent in the specimens examined.

Crania of *Daption capense*

No.	Collector	Locality	Date	Exposed Culmen (Approx.)	Total Length	Fronto-median Tract
B13498	Miss J. Cleland	Encounter B., S.A.	-/9/1930	30	78	4
B18018	B. C. Cotton	Yorke Penin, S.A.	-/9/1935	26	72	3
B22084	A. Ey	South east, S.A.	-/11/1939	31	81	3
B22085	" "	" " "	/11/1939	30	79	2.5

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THE CAMBRIAN SEQUENCE IN THE WIRREALPA BASIN

By D.MAWSON

Summary

This is another of a series of contributions recording field observations undertaken with a view to elucidating the character and succession of the older rocks of South Australia. The Mines Department has recently issued a publication (Segnit, 1939) bearing upon this same theme. As a consequence, information relating to the chronology of the older formations of the State is now rapidly accumulating

THE CAMBRIAN SEQUENCE IN THE WIRREALPA BASIN

By D. MAWSON

[Read 12 October 1939]

This is another of a series of contributions recording field observations undertaken with a view to elucidating the character and succession of the older rocks of South Australia. The Mines Department has recently issued a publication (Segnit, 1939) bearing upon this same theme. As a consequence, information relating to the chronology of the older formations of the State is now rapidly accumulating.

The present paper deals with the Cambrian sequence as recorded in the most complete succession of strata of that age known to exist within the boundaries of the State. The locality is that of the eastern margin of the Flinders Ranges in the neighbourhood known as The Bunkers. Elsewhere in South Australia are known many localities where there occur excellent exposures of strata representative of the lower portion of our Cambrian sediments, beds typified by abundance of Archaeocyathinae. Howchin (1922) was the first to locate, in the neighbourhood of Wirrealpa and The Bunkers, beds superior in position to the Archaeocyathinae-bearing series but still carrying Cambrian fossils, namely, *Obolella*, *Girvanella* and *Redlichia*. However, the thickness of these beds and their relation to the underlying Archaeocyathinae bearing terrain he did not establish. That locality is, therefore, of special stratigraphical interest, deserving more detailed investigation than could be achieved in the course of Howchin's short visit. Accordingly, the author has examined that area on several occasions during the past decade.

Howchin's remarks are illustrated by a sketch-section across the strike of the beds where investigated in the vicinity of Balcoracana Creek. That section, however, was not accurately measured and purports to give only a rough representation of the relations of the beds. In any case, the line of section is intersected in two zones by notable faults which result in misrepresentation of the true sequence.

We have not only measured the beds met with in a traverse through the series at Balcoracana Creek but located and measured a more complete and less disturbed cross-section of the Cambrian beds as met with in the vicinity of the Ten-Mile or Billy Creek. The localities of both of these sections are shown on the map, fig. 1.

We are mainly concerned with the Ten-Mile Creek section. However, neither locality is free from strike faults, consequently, both of the traverses are mutually helpful in arriving at the true Cambrian sequence. Details of both are set forth below and the Ten-Mile Creek section is graphically represented in fig. 2. The examination of the beds has been spread over several field sessions with students. Of the latter, L. W. Parkin and W. B. Dallwitz have been most concerned.

The locality map, which constitutes fig. 1, is not to be regarded as accurate to scale in any of its details for, as regards the topographical features, it is almost in its entirety a copy of the pastoral plan published by the Lands Department. As is well known, the detail of these plans is often very far from accurate. The rough indication of the distribution of the several stratigraphical units shown by hatching is no more accurate than the map itself. In fact, it is intended merely to broadly indicate the area occupied by outcropping Cambrian sediments.

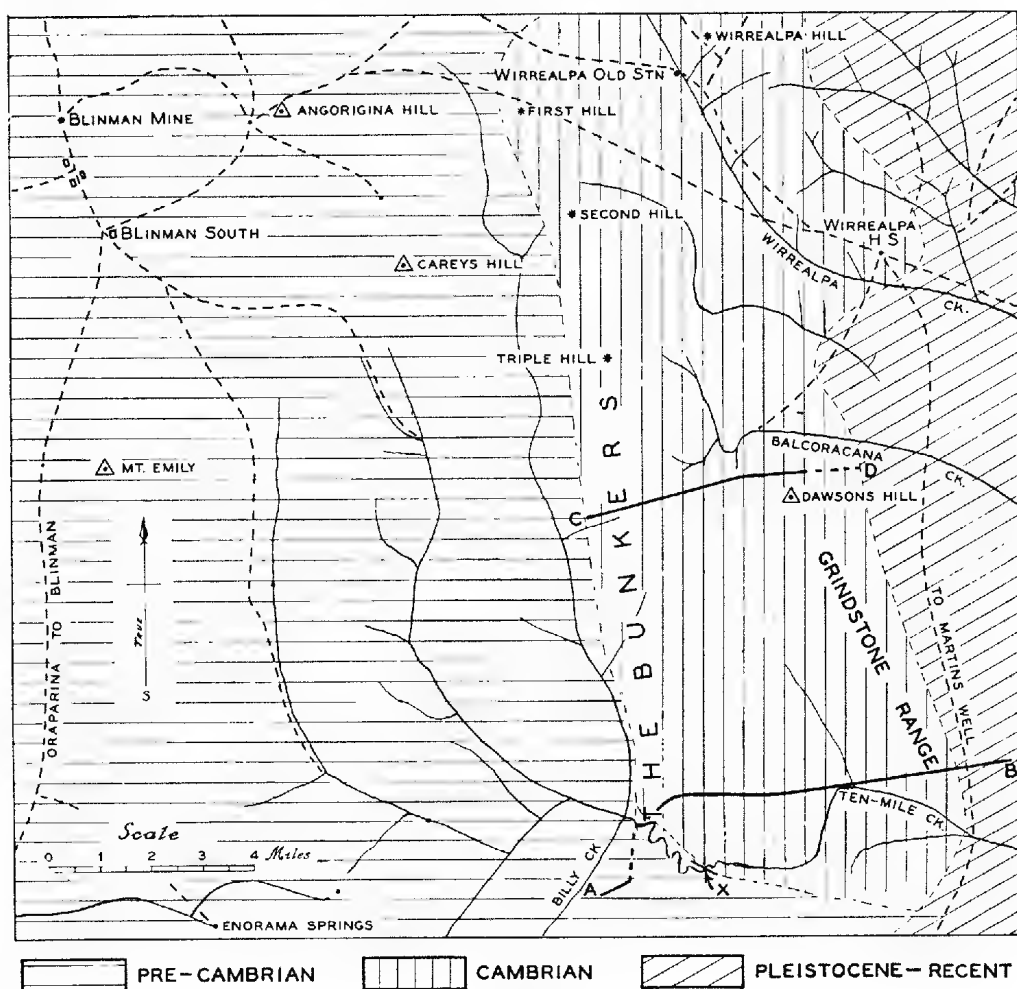


Fig. 1

The range of hills known as The Bunkers extends for a length of about 25 miles, where it forms the eastern margin of the Flinders Ranges. It stretches southward from a point about due east of Blinman. The Big Hill (First Hill) on the Blinman-to-Wirrealpa Road, at about 12 miles east of Blinman, may be taken as the northern limit of The Bunkers line of range. To the south it extends and includes the Mount Caernarvon Range.

Throughout its length this range of hills is composed of a thick succession of sediments with a general easterly dip. Though important lines of faulting and some buckling are apparent, the region as a whole is less disturbed than are most areas of these old rocks.

To the south, in the Mount Caernarvon Range, the Pre-Cambrian tillite and fluvio-glacial beds constitute the highest hills. North of the Ten-Mile Creek, the higher topographical features are carved out of the Archaeocyathinae belt of the Cambrian and the eastern foothills are occupied by the upper series containing *Redlichia*. The latter also occupy the low undulating country in the immediate vicinity of Wirrealpa Head Station and for five miles to the west therefrom. This pocket of Cambrian strata does not extend far to the north of Wirrealpa Head Station, for it is there cut off by faulting. Immediately south of the Ten-Mile Creek, Cambrian beds turn towards the south-east, then east, disappearing beneath the plains.

Above the fossiliferous *Obolella-Girvanella* horizon of the upper beds the formation continues as a vast thickness of sandy sediments, softer and more argillaceous below, but more resistant above. The topmost beds of this post-Archaeocyathinae formation are sandstones weathered out in relief and constituting the Grindstone Range or Little Bunkers.

THE TEN-MILE CREEK SECTION ACROSS THE BUNKERS AND GRINDSTONE RANGE

This section was run across the strike of the formations along the line A-B indicated on the plan, fig. 1. The beds represented are listed under eighty-one successive items. The succession commences in strata regarded as of Proterozoic age. Number one of the column is at the base.

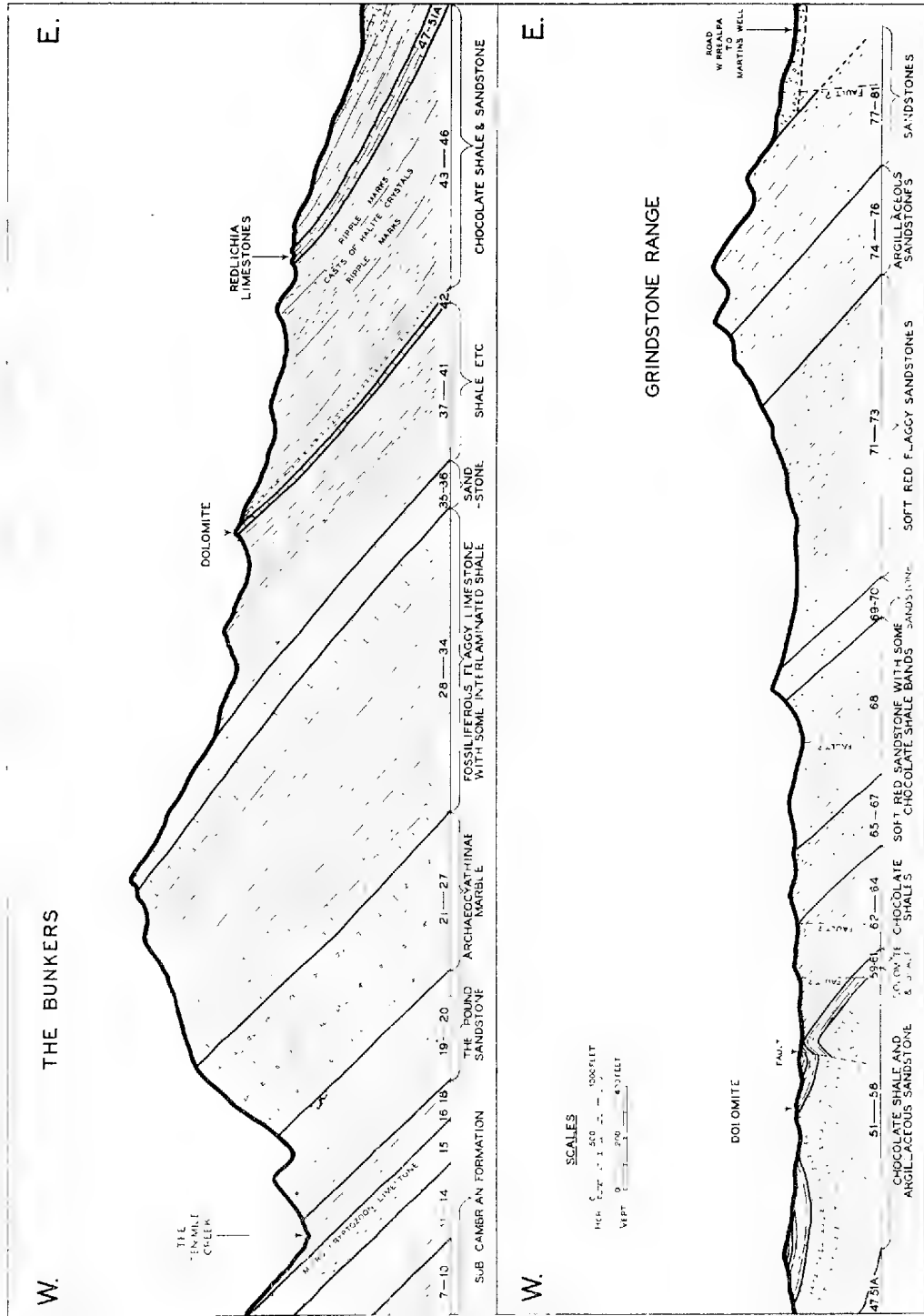
The figures given below as the thickness of the respective beds are true thicknesses deduced from the measurement of outcrop widths. The compass bearings given are "true," not "magnetic."

The continuation of the beds above item (81) cannot be followed, for they pass beneath the Pleistocene pebble beds veneering the plain bordering Lake Frome. A somewhat greater thickness appears to be exposed at the northern end of the Range.

RESISTANT SANDSTONES OF THE GRINDSTONE RANGE

Aggregate thickness, 870 feet

- 81 156 ft. of reddish-coloured sandstone. Occasional bands containing small water-worn pebbles of quartzite were observed in the upper portion of this belt. Pseudo-fossil impressions of the clay-pellet type occur in this division. In microscope section, the mineral grains are seen to be angular though slightly more rounded than in the case of the hard sandstone of (79). Patches showing aggregate polarization represent former silicate particles, probably feldspar, now kaolinised. Tiny grains of tourmaline are not uncommon. Zircon particles are rare.



- 80 158 ft. of soft, white, even-grained sandstone. This carries a considerable amount of interstitial white kaolin.
- 79 480 ft. of fine-grained, comparatively hard, white sandstone. Weathered surfaces usually appear of a reddish to purple colour. Dip, 42° towards N. 45° E. (true).
- The microscope slide shows this to be of an even grain-size, and composed of angular particles of quartz amongst which fragments of tiny prisms of zircon are not uncommon.
- 78 42 ft. of thin-bedded sandstone with white clay partings.
- 77 190 ft. of thick-bedded sandstone.

CHOCOLATE SHALES AND SOFT FLAGGY SANDSTONE

Aggregate thickness, 6,410 feet; however, as the beds are folded and faulted, the true thickness is probably much less.

- 76 40 ft. of soft sandstone flags alternating with shales. This sandstone weathers characteristically, developing abundant, regularly distributed, small pits on the exposed surface.
- 75 245 ft. of sandstone.
- 74 480 ft. of reddish, thin-bedded, flaggy sandstone. Dip, 48° .
- 73 340 ft. of sandstone and sandy, chocolate-coloured shales. Dip, 48° to N. 50° E. (true).
- 72 1,390 ft. of soft, flaggy sandstone, argillaceous sandstone, sandy shale and chocolate shale. Dip, 48° to N. 50° E.
- 71 820 ft. of reddish-coloured, flaggy, soft sandstone.
- 70 260 ft. of sandstone, more massive below but passing up into a thinner-bedded form above.
- 69 150 ft. of white to light pink, thin-bedded, flaggy sandstone.
- 68 1,370 ft. of soft, flaggy sandstone. Outcrops coloured pink to reddish.
- 67 290 ft. of moderately hard, flaggy sandstone with occasional bands of chocolate coloured shale.
- 66 118 ft. of soft sandstones with a little chocolate shale.
- 65 72 ft. of sandstone; flaggy below to massive above.
- 64 540 ft. of shales passing up to soft sandstone above. These beds are but poorly exposed on low ground. The nature of the surface shoad indicates that the shales include some thin bands of a calcareous nature.
- 63 245 ft. of chocolate shales passing into greenish-grey shales above.
- 62 50 ft. of chocolate shales. Dip, 33° to N. 55° E.

CHOCOLATE SHALES AND CHERTY DOLOMITE

Aggregate thickness, 76 feet.

- 61 6 ft. of dolomite. Nodules of a flinty chert are distributed through it. Dip, 15° .
- 60 60 ft. of chocolate shales.
- 59 10 ft. of sandy dolomite with chert nodules.

CHOCOLATE SHALE AND RED SANDSTONE

Aggregate thickness, 1,326 feet

- 58 230 ft. of soft chocolate shale and sandstone; more richly arenaceous near the upper limit.
- 57 100 ft. of soft chocolate shale and sandstone.
- 56 40 ft. of chocolate sandstone, with one very thin band of limestone. Dip, 25° to N. 85° E.
- 55 272 ft. of soft shales. Outcrop largely hidden beneath soil.
- 54 180 ft. of red sandstone. Dip, 35° to N. 85° E.
- 53 95 ft. of somewhat calcareous sandstone.
- 52 9 ft. of calcareous sandstone.
- 51B 400 ft. of soft argillaceous sandstone and shale; outcrop wanting.

FOSSILIFEROUS LIMESTONE

Aggregate thickness, 317 feet

- 51A 100 ft. of nodular limestone embedded in a greenish-grey marly base. *Girvanella* contributes to this calcareous formation.
- 50 100 ft. of limestone, rich in *Obolella*.
- 49 40 ft. of fossiliferous limestone, rich in ill-defined fragmentary remains.
- 48 165 ft. of knobbly, argillaceous limestone. Irregular calcareous nodules are thickly packed in a greenish-grey, calcareo-argillaceous base. This resembles item (51A).
- 47 12 ft. of hard, dark-coloured limestone rich in faintly-defined fossil remains. Dip, 45° to N. 85° E. In the microscope slide, the rock is observed to have been extensively recrystallised and to contain detrital biotite.

CHOCOLATE SANDSTONE AND SHALE

Aggregate thickness, 1,730 feet

- 46 320 ft. of flaggy, chocolate sandstone and chocolate shales.
- 45 160 ft. of sandy chocolate shales.
- 44 1,150 ft. of chocolate shales exhibiting excellent ripple marks, and with well-preserved cuboidal casts after halite crystals.
- 43 100 ft. of light-red and grey calcareous shales with a bar of pink sandstone 2 ft. thick located at 75 ft. above the base of this section.

DOLOMITE

- 42 15 ft. of massive dolomite. Dip, 48° to E. 50° S (true).

CHIEFLY CHOCOLATE SHALES

Aggregate thickness, 650 feet.

- 41 100 ft. of chocolate shale and thin-bedded sandstone.
- 40 400 ft. of chocolate shale with a calcareous band one foot thick at about 150 ft. from the bottom of the section.
- 39 150 ft. of shale, partly grey-coloured (lower portion).

FLAGGY LIMESTONE

- 38 50 ft. of flaggy limestone with some interbedded shale.

GREY SHALE

- 37 700 ft. of soft, grey-green shale; on the weathered surface, breaking down to tiny chips.

SANDSTONE

Aggregate thickness, 445 feet

- 36 400 ft. of sandstone dipping at 36° . In the main this is of a white to buff colour, but weathers to brown and reddish tints. In microscope section a specimen of the hard rock from near the base of this quartzite was found to be composed of fine, even-sized quartz grains. The presence of occasional tiny prisms of zircon was noted. The lower 200 ft. of this formation is harder and more resistant than the upper beds.
- 35 45 ft. of passage beds initiating new conditions of sedimentations. These are of the nature of impure sandy limestone below, passing upwards into alternating bands of clay-shale and hard sandstone.

DARK GREY TO BLACK FOSSILIFEROUS, FLAGGY LIMESTONE

Aggregate thickness, 1,250 feet

- 34 90 ft. of laminated, black calcareous flags. Occasional *Archaeocyathinae* and Sponge spicules were observed faintly outlined on the weathered surface. Dip, 40° towards E. 15° S. (true). The microscope section reveals that the delicate banding is due to alternating laminae of coarser and finer grain. Amongst the grains of inorganic matter, there are visible in the slide minute perforated particles of organic origin which exhibit a regular pattern. These may be broken fragments of Diatoms, Radiolaria, or portions of the wall of an *Archaeocyathus*. Unfortunately, these remains so far as yet observed have been too fragmentary for satisfactory solution.
- 33 520 ft. of flaggy, dark-grey to black limestones. These weather to a lighter colour. They differ very little from the underlying division (32). Not infrequently the elongated forms of *Salterella* appear weathered out in relief on the surface. Several examples of an *Archaeocyathus* were collected in this division. These were mainly met with in the upper section.
- 32 640 ft. of dark-coloured and flaggy limestone, which weathers to grey and buff-coloured outcrops. At the top of this division is a partly silicified band, some 2 ft. thick, in which are traces of fossils. Indistinct fossil markings are also noted on the outcrop at many places. Only near the upper limit was a definite and distinct *Archaeocyathus* observed.

FOSSILIFEROUS, FLAGGY LIMESTONE, IN PART INTERLAMINATED WITH SHALE

Aggregate thickness, 550 feet

- 31 125 ft. of dark grey, flaggy limestone with shale partings. Dip, 45°.
- 30 125 ft. of flaggy, laminated, impure limestone. On the weathered outcrop, faintly outlined, was noted a single example of a cup-shaped form resembling an *Archaeocyathus*.
- 29 205 ft. of bedded flags of a calcareo-argillaceous nature. Argillaceous bands regularly alternate with calcareous bands each several inches thick. In the upper part of this section the limestone element is reduced to mere strings of plates embedded in the argillaceous element. Cup-shaped fossil sponges are met with near the top of this division.
- 28 95 ft. of thin-bedded, flaggy, impure limestone. Cryptozöonic structure noted; also an *Archaeocyathus* was observed in the rock near the upper limit of this division. Silicification evidenced, with the development of chert nodules.

ARCHAEOCYATHINAE MARBLE

Aggregate thickness, 1,240 feet

- 27 294 ft. of grey, impure limestone for the most part exhibiting nodular Cryptozöonic markings. These beds are flaggy to massive. Silicification is evidenced in some bands. No definite Archaeocyathinae were seen, but faint markings appear to represent the almost obliterated remains of such.
- 26 116 ft. of very richly fossiliferous Archaeocyathinae marble.
- 25 251 ft. of dense limestone partly pervaded by a grey tracery. This division except in its lowest part is very rich in Archaeocyathinae. Some silicification evidenced. Dip, 45° to E. 15° S. (true).
- 24 290 ft. of dense limestone rich in well-preserved Archaeocyathinae.
- 23 88 ft. of limestone with some Cryptozöon structures and occasional Archaeocyathinae.
- 22 60 ft. of dense, grey marble in which no Archaeocyathinae were seen.
- 21 141 ft. of a grey marble rising above to a white massive form at the upper limit of the section. Cryptozöonic structures were observed in the lower grey rock.

THE POUND SANDSTONE FORMATION

Aggregate thickness, 800 feet

- 20 500 ft. of sandstone, mainly reddish in colour but incorporating a white section near its upper limit. Dip, 45° to E. 15° S.
- 19 300 ft. of pink to red-coloured flaggy sandstones with partings of ripple-marked shale. Pellet clots are present in several bands of the sandstone. Smooth curved impressions not unlike moulds of molluscan valves were observed in this division, but not sufficiently definite to establish them as of fossil origin.

SUB-CAMBRIAN FORMATIONS

- 18 50 ft. of reddish-coloured shale and silt-stone exhibiting strongly ripple-marked bedding planes.
- 17 30 ft. of buff-coloured limestone. On the line of section this is hidden by a veneer of river wash, but further north along the line of strike it forms a massive outcrop.
- 16 180 ft. of grey argillaceous limestone and shale. Crossing the line of section, the bed of the Ten-Mile Creek is carved in this division.
- 15 250 ft. of coarse, flaggy limestone and finely laminated limestone. These are usually notably argillaceous. Interbedded with them are two belts of shale. Micro-cryptozöon structure is well exemplified in these beds and some nodular stromatolitic forms were observed.
- 14 172 ft. of flaggy, argillaceous limestones.
- 13 175 ft. of somewhat calcareous, argillaceous flags and shales. In these a grey colour dominates but the more highly weathered rock has become reddened.
- 12 70 ft. of shales which are practically non-calcareous. Some of the laminae are of silt and very fine-grained sand.
- 11 45 ft. of grey shales which on the weathered surface break down into coarse chips.
- 10 220 ft. of thinly-laminated, non-calcareous flags with some calcareous intercalations.
- 9 85 ft. of brown micaceous flaggy slate.
- 8 230 ft. of somewhat calcareous slates.
- 7 52 ft. of chocolate slates which, along the weathered outcrop, are broken down to small chips.
- 6 54 ft. of siliceous flags.
- 5 370 ft. of thin bedded, chocolate slates. This section is seamed with belts in which silicification, bleaching and other chemical alterations have been effected by mineralizing solutions. Some calcium, iron and magnesium carbonates and much baryta have been deposited in these channels.
- 4 60 ft. of hardened, silicified, grey flaggy shale.
- 3 340 ft. of chocolate shale.
- 2 250 ft. of a reddish series of thin, flaggy sandstones with shale partings.
- 1 20 ft. of hard, reddish sandstone in which the bedding plane is clearly defined by laminations.

Below this horizon chocolate shale and soft sandstone are showing in the flat country lying further to the west, but outcrops are only occasional owing to a cover of alluvial wash and soil. Marked changes in the direction of strike are shown in this area, indicating considerable disturbance.

SECTION ACROSS THE STRIKE IN THE NEIGHBOURHOOD OF BALCORACANA CREEK
SANDSTONES CONSTITUTING THE GRINDSTONE RANGE

In this locality the thickness of the strong, flaggy to thick-bedded sandstones which stand out in bold relief as the Grindstone Range, was not measured. However, a rough estimate indicates a thickness of between 1,000 and 2,000 feet. The beds listed below all lie west of the Grindstone Range and almost certainly do not include any repetition of the strata represented in that Range.

DISTURBED BELT OF SEDIMENTS IMMEDIATELY UNDERLYING
THE GRINDSTONE RANGE

1,770 ft. (estimated at an average dip of 42°) of soft, reddish, flaggy sandstone, in part argillaceous. This division may include several strike faults. An extremely disturbed belt near the top of this division is indicated as a definite line of notable strike faulting.

SOFT SANDSTONES

(Aggregate thickness, 1,675 ft., corresponds to beds immediately above item (64) of the Ten-Mile Creek section.)

- 5 ft. of chocolate slate. Dip, 42° . Strike, $N. 4^{\circ} W.$ (true).
- 270 ft. of soft sandstone. Average dip, 41° ; and strike, $N. 5^{\circ} W.$ Some disturbance in this division indicates the probability of faulting having taken place.
- 100 ft. of flaggy, fissile sandstone. Part of this division is curiously spotted, expressed on the weathered surface of the rock by a characteristic pitting.
- 940 ft. of flaggy, fissile sandstone, in part micaceous and laminated. Dip, 42° . Strike, $N. 5^{\circ} W.$
- 160 ft. of strong sandstone. Dip, 42° . Strike, $N. 7^{\circ} W.$
- 200 ft. of soft laminated, micaceous sandstone. The laminae over part of this division range from $\frac{1}{16}$ to $\frac{1}{8}$ inch in thickness.

CHOCOLATE SHALE WITH LIMESTONE BANDS

(Apparently corresponding to items (62), (63) and (64) of the Ten-Mile Creek section)

345 ft. of fissile chocolate shale with interbedded bands of buff-coloured limestone, ranging in thickness from a few inches to 2 feet. The limestone intercalations have a greater average thickness in the lower part of this division than in its upper extension. Dip, 42° .

CHOCOLATE SHALE AND CHERTY DOLOMITE

(Aggregate thickness, 73 ft., corresponds to items (59), (60) and (61) of the Ten-Mile Creek section)

- 5 ft. of buff-coloured limestone carrying large nodules of flinty chert.
Dip, 45°.
- 60 ft. of chocolate shale.
- 8 ft. of dolomite with chert nodules.

CHOCOLATE SHALE AND RED SANDSTONE

(Aggregate thickness, 1,056 ft., corresponds to items (51 B) up to and including (58) of the Ten-Mile Creek section)

- 122 ft. of chocolate shale, sandy near the base.
- 170 ft. of soft, red sandstone.
- 168 ft. of chocolate shales with occasional belts of a grey colour associated with rather frequent thin calcareous bands.
- 55 ft. of sandy chocolate shale.
- 43 ft. of soft, red sandstone.
- 44 ft. of thinly-laminated, soft, chocolate-coloured, sandy shale.
- 145 ft. of soft, red sandstone.
- 235 ft. of sandy, chocolate shale.
- 74 ft. of beds partly hidden by alluvium; apparently soft shale.

FOSSILIFEROUS LIMESTONE

(Aggregate thickness, 344 ft., corresponds to items (46) to (51A) of the Ten-Mile Creek section)

- 69 ft. of nodular Cryptozöonic limestone, in part somewhat marly. A strongly marked band, 2 feet thick, rich in coarse *Girvanella*, is located at 27 feet above the base of this section. Some Pteropods were noted in the *Girvanella* band.
- 31 ft. of nodular, somewhat marly limestone. *Girvanella* is present both in coarse and fine centric structures.
- 47 ft. of flaggy limestone with some reddish-brown silicified traceries raised in relief on the weathered face. In the centre of this section there is a strong band rich in *Girvanella*. A thin band of intraformational breccia was observed in this section.
- 14 ft. of rubbly, nodular limestone terminated above in a well defined band of *Obolella* limestone.
- 9 ft. of nodular, marly limestone in which *Girvanella* and Cryptozöonic stromatoliths occur.
- 106 ft. of soft shale, coloured greenish-grey. This is marly in part and becomes nodular towards its upper limit.
- 24 ft. of Pteropod and *Obolella* limestone embedded in which at the upper limit of this section are fragments of Trilobites; also nodular *Girvanella* limestone.
- 40 ft. of dense dark-coloured limestone with some fossil markings.

CHOCOLATE SHALE AND RED SANDSTONE

(Aggregate thickness, 930 ft., corresponds to items (44) to (46) of the Ten-Mile Creek section)

- 50 ft of chocolate-coloured beds, which are arenaceous below but upwards pass into ripple-marked shale with casts of halite crystals.
- 90 ft. of a strong, red sandstone forming a high ridge. Dips up to 48° noted.
- 560 ft. of a chocolate-coloured series of the nature of ripple-marked slate below but becoming more arenaceous towards the upper limit. Casts of halite crystals were met with in the ripple-marked shale.
- 210 ft. of ripple-marked chocolate shale. Dip, 25° to 30° .
- 420 ft. of chocolate slate, poorly exposed.

DISTURBED AND GREATLY FAULTED BELT

Shattered chocolate shale and other beds partly hidden by a horizontal cover of recent alluvium occupy a distance across the strike equivalent to a thickness of 1,000 ft. of strata. It is evident that in this neighbourhood the normal sequence of beds has been disturbed by large-scale elimination effected by strike faults. Items (28) up to and including part of (44) of the Ten-Mile Creek section are involved in this crushed and faulted belt.

ARCHAEOCYATHINAE MARBLE

- 950 ft. of Archaeocyathinae marble. Dip ranges from 26° to 30° . A narrow oolitic band, somewhat silicified appears in the basal part of this formation. At its upper limit the marble is shattered by severe strike faulting. Equivalent strata in the Ten-Mile Creek section are items (21) and (27).

THE POUND SANDSTONE FORMATION

A thick formation of red sandstone. Dip is 30° , strike N. 10° W. (true). Immediately below the overlying limestone this formation is slightly argillaceous and softer. This corresponds to item (20) of the Ten-Mile Creek section.

NOTES ON THE COMPOSITION OF SOME OF THE CALCAREOUS FORMATIONS

With a view to ascertaining to what extent the limestones have been dolomitized, a rough chemical examination was undertaken by W. B. Dallwitz, with the following results.

Three variants were selected out of a collection of specimens from the great belt of Archaeocyathinae marble, items (21) to (27) of the section.

- (a) White Marble — Calcium carbonate 98.3%, magnesium carbonate 0.8%, ferric oxide and alumina 0.3%, insoluble 0.5%.
- (b) Pink Marble — Calcium carbonate 97.4%, magnesium carbonate 1.2%, ferric oxide and alumina 0.4%, insoluble 1.6%.

(c) Dark-grey Marble — Calcium carbonate 92·7%, magnesium carbonate 6·0%, ferric oxide and alumina 0·4%, insoluble 1·6%.

Materials from other horizons gave the following results:

Flaggy limestone, item (38) of the section:

Calcium carbonate 81·5%, magnesium carbonate 5·7%, ferric oxide and alumina 1·1%, insoluble 11·6%.

Massive dolomite, item (42) of the section:

Calcium carbonate 36·1%, magnesium carbonate 26·8%, ferric oxide and alumina 3·1%, insoluble 34·5%.

Dark-coloured limestone, item (47) of the section:

Calcium carbonate 92·6%, magnesium carbonate 5·2%, ferric oxide and alumina 0·5%, insoluble 2·1%.

Flaggy *Obolella* limestone, item (50) of the section:

Calcium carbonate 89·5%, magnesium carbonate 5·6%, ferric oxide and alumina 1·5%, insoluble 3·5%.

Dolomite, item (61) of the section:

Calcium carbonate 51·3%, magnesium carbonate 29·6%, ferric oxide and alumina 4·1%, insoluble 13·6%.

The phosphorous content of some of these Cambrian limestones was determined with the following results.

The dark-coloured limestone of item (47) of the Ten-Mile Creek section yielded 0·03% P_2O_5 . The corresponding limestone of the Balcoracana Creek section (40 feet thick at the base of the fossiliferous section) contains 0·02% P_2O_5 .

A band of *Obolella* limestone, in which Pteropods and fragments of Trilobites are visible, taken from the upper limit of the 24-ft. band overlying the basal dark-coloured limestone of the Balcoracana Creek section, yielded 0·22% P_2O_5 .

Specimens collected from the fossiliferous limestones outcropping immediately west of Wirrealpa Head Station were also tested. Of these a sample of a large spherical nodule of *Girvanella* returned 0·04% P_2O_5 . Another sample, rich in *Girvanella* balls and radial oolites, was found to contain 0·05% P_2O_5 .

THE PRESENCE OF CARBON AND HYDROCARBONACEOUS SUBSTANCES

A notable feature of certain horizons of the late Pre Cambrian and Cambrian sequence of South Australia is the presence therein of uncombined (apparently graphitic) carbon, and traces of hydrocarbonaceous substances. It is probable that in the long past these horizons were source rocks of petroleum oil, but now only the merest vestiges remain. The following cases may be mentioned:

- 1 A black argillite of Pre-Cambrian age in Arcoona Valley, item (55) of the Brachina Creek section as recorded in a previous publication (Mawson, 1939), emanates a faint bitumenous odour on freshly quarried faces.
- 2 Black calcareo-argillaceous shales and impure limestones of Cambrian age which overlie the Archaeocyathinae marbles in several localities in South

Australia, owe their colour to the presence of carbon. Such are recorded in the Ten-Mile Creek section of this report as items (32) to (34). The equivalent of these beds in the neighbourhood of Adelaide is met with as black calcareo-argillaceous shales above the Archaeocyathinae marbles at Sellick's Hill.

- 3 The fossiliferous limestones of the upper divisions of the Cambrian in the Wirrealpa basin carry traces of hydro-carbon oils. This is especially to be remarked in item (47) of the Ten-Mile Creek section. The same feature has been observed where this same limestone was met with in traversing the Balcoracana Creek section.

W. B. Dallwitz, when determining the lime-magnesium content of the rocks, as recorded above, was the first to observe the presence of traces of hydro-carbon oils in these limestones. He later noted that a bitumenous odour was emitted when grinding certain of the limestones.

With a view to ascertaining the carbon and hydrocarbon contents, T. W. Dalwood, analyst to the South Australian Mines Department, kindly examined specimens of several of these and reports as follows: Black shale from Aroona Valley (No. 1 locality) contains a trace of hydrocarbonaceous matter and 2.05% of uncombined carbon. Black shale from Sellick's Hill (No. 2 locality) contains, besides a trace of hydrocarbonaceous substances, uncombined carbon to the extent of 1.96%. Limestone of item (47) of the Ten-Mile Creek section is reported as containing a trace only of hydrocarbons. The same also is reported from the corresponding limestone of the Balcoracana Creek area.

REVIEW OF THE FORMATIONS REPRESENTED

Though the above cross-sections of the Cambrian basin in the neighbourhood of The Bunkers include disturbed and faulted zones, the general sequence is clear. In the case of the Ten-Mile Creek section, the formation appears to be practically unbroken by dislocations of any note from an horizon well below the base of the fossiliferous Cambrian, upwards through over 7,000 feet of Cambrian sediments. Still higher in the succession, a thick, unfossiliferous series of chocolate shale with some bands of dolomite and a great development of sandstone continue upwards for a further minimum thickness of several thousand feet. In the estimation of the total thickness of this latter division, uncertainty is introduced on account of disturbance by folding and faulting. These irregularities are localized in a region of little surface relief, where outcrops are poorly displayed for their satisfactory interpretation. However, we believe that the structure has been sufficiently elucidated to allow of an approximate estimation of the thickness of this disturbed section. The rocks traversed can be considered in four main divisions.

THE UNFOSSILIFEROUS PRE-CAMBRIAN BASEMENT

At the base are slates, limestones and sandstones which are quite normal in sequence in comparison with similar beds underlying the fossiliferous Cambrian as recorded elsewhere in the Flinders Ranges. These may be assumed to be Pre-

Cambrian though in the case of the thick sandstone-quartzite immediately underlying the Archaeocyathinae marble, I have, in earlier contributions, tentatively regarded it as representing the base of the Cambrian sequence. Segnit (1939), however, regards this sandstone as the topmost member of the Pre-Cambrian. Where the line of section crosses the Ten-Mile Creek, the exposed contact between this sandstone and the Archaeocyathinae marble, shows no sign of unconformity.

About $2\frac{1}{2}$ miles down the creek below the line of section, the gorge of the Ten-Mile Creek turns across the strike of the Cambrian beds and continues thus for some distance. This is at the point marked X on the map, fig. 1. A splendid cross-section of the junction between the underlying sandstone and the Archaeocyathinae marble is revealed, but there appears to be no evidence of an erosion interval though there is some evidence of overlap.

It may be urged that erosion is suggested by the fact that this sandstone is upwards of 3,000 feet thick in the neighbourhood of Wilpena Pound and the Brachina Creek Gorge, whereas here as the Ten-Mile Creek it is only 800 feet thick. This is to be explained as follows.

The evidence available indicates that the land from which the sand constituting this huge deposit was shed lay not far to the west of Wilpena Pound. The present line of the western margin of the Flinders Ranges probably coincides with the near-shore margin of the off-shore geosyncline of those days. In this circumstance it is to be expected that the arenaceous deposition equivalent to the extraordinarily massive sandstone constituting Wilpena Pound diminished in thickness with progress to the east. The region of The Bunkers is about 25 miles from the western margin of the Flinders Range. The sediment now constituting The Bunkers was originally deposited still further to the east, but brought into closer proximity to the western side of the Range by subsequent great diastrophic movements which have folded the beds as we now find them. Thus may be explained the equivalence of the 800 feet of sandstone in The Bunkers to the much greater thickness in the vicinity of Wilpena Pound.

THE ARCHAEOCYATHINAE-BEARING CAMBRIAN SERIES

This division totals somewhat more than 3,000 feet in thickness. It is characterised by abundance and variety of forms of Archaeocyathinae. In part this is a massive development of white limestone 1,250 feet thick, resembling in character coral reef growths of later times.

The upper beds of this division of the Cambrian are in the main dark-coloured, flaggy, impure limestones with, in part, some laminated, calcareous shale. Fossils are less abundant, though Archaeocyathinae, Pteropods (*Salterella*), Sponges and Cryptozöonic-like stromatolites are to be met with as macroscopic forms. We did not locate any Trilobites. However, quite similar Archaeocyathinae-containing beds in southern South Australia have yielded *Protolenus*.⁽¹⁾ Thus this division has been assigned to the Lower Cambrian.

(1) Determination by F. W. Whitehouse.

Redlichia-BEARING-CAMBRIAN SERIES

This formation follows upon the foregoing but is of an entirely different nature. Deposition under hot and highly arid climatic conditions is indicated by the prevailing red and chocolate colour of the sediments and by the presence of casts of salt (halite) crystals originally embedded in the muds. For the most part, the deposits were laid down in very shallow water as attested by the prevalence of ripple marks. It is probable that the bulk of these sediments was deposited under terrestrial conditions in shallow fresh-water sheets which periodically became dried up salt pans marginal to the sea. At one stage the sea gained entrance to the area and a thickness of 317 feet of marls and marine fossiliferous limestone was laid down. This limestone is remarkably rich both in *Girvanella*, *Obolella* and *Hyolithes*. Fragments of Trilobites are also numerous at one horizon. Some years ago, Trilobite remains were recovered from this same horizon by Howchin and were described by Etheridge (1905). More recently, F. W. Whitehouse has checked over the determination of these Trilobite remains and advises⁽²⁾ that there can be no doubt as to their being referable to *Redlichia*, indicating an upper Lower-Cambrian or lower Middle-Cambrian age.

The base of this division is a strongly developed sandstone which appears to rest conformably on the underlying Archaeocyathinae series. The thickness of this arenaceous bed, which commenced a new cycle of deposition, is given as 445 feet, which includes the underlying passage beds as well as the main sandstone.

The shales immediately above the sandstone are greenish-grey, but thereafter all sediments, with the exception of the marine fossiliferous phase, are reddish or chocolate-coloured, indicative of the oncoming of aridity. It is also notable that all limestones of this arid section contain a notable amount of magnesia and in two cases are dolomites.

The marine fossiliferous section which is scheduled as 317 feet in thickness is a very characteristic and persistent belt. It has been observed to extend in a curving but unbroken line across the country from about 1 mile to the south of the line of the Ten-Mile Creek section northward to cross the Wirrealpa Head Station-to Blinman track at a point 2 miles south of Wirrealpa Old Station building; from there it extends a little further to the north, then swings to the east. The same fossiliferous belt comes to the surface again in the vicinity of the Head Station buildings. It was in the section exposed in the creek at this latter locality that Howchin first discovered fragments of Trilobites.

When dealing with the fossil remains, more details will be supplied later concerning this interesting horizon.

The aggregate thickness of this division is taken to be about 5,380 feet. This figure is arrived at by combining the sum of item (35) to (51 A) (unbroken sequence) of the Ten-Mile Creek section with the unbroken sequence above the fossiliferous horizons of the Balcoracana Creek section, namely, up to and includ-

(2) Private communication.

ing the 345 feet of "chocolate shale with limestone bands." Above this latter horizon is an immense thickness of sandstone which is better considered as a fourth division.

THICK SANDSTONE FORMATION

A fault belt through this formation complicates the problem of accurately computing its thickness. Assuming that the faulting has not introduced duplication of strata, the thickness of this division as indicated by the figures for the Ten-Mile Creek section is 6,935 feet, but in the case of the Balcoracana Creek traverse, a thickness of only 5,445 feet is accounted. Thus serious error occasioned by the faulting is apparent. The true thickness, however, cannot be less than about 3,500 feet, which is the approximate thickness of the sandstone belt as met with in the Balcoracana Creek traverse, less the 1,770 feet of extremely disturbed beds.

But the topmost beds of sandstone observed, which form the eastern margin of the Grindstone Range, are not necessarily the topmost beds of this formation. Still higher beds are probably hidden beneath the eastern plain. It is to be remarked that this sandstone shows evidence of becoming progressively coarser at higher elevations in the series; the last exposed beds actually carrying occasional pebbles. Thus it would appear that the land margin was steadily progressing eastward during the period of deposition of this formation.

As to the age of this great sandstone belt, all that can be said in the absence of fossils, is that it is conformable with the underlying *Redlichia*-bearing series. Also, the sedimentary types represented have affinities with the underlying series. The conclusion, therefore, is that these unfossiliferous sandstones are also of Cambrian age and may be either Middle- or Upper-Cambrian.

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ON MAMMALS FROM THE LAKE EYRE BASIN PART V

General remarks on the increase of murids and their population movements in the Lake Eyre Basin during the years 1930-1936.

By H. H. FINLAYSON

Summary

As indicated in Part IV of this series (2), two species of murids were in process of rapid increase during my stay in the district in December, 1931. The increases culminated some four months later, in one of several peak periods distributed over the years 1930-1936, each one of which might, without exaggeration, be called a plague.

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PART V

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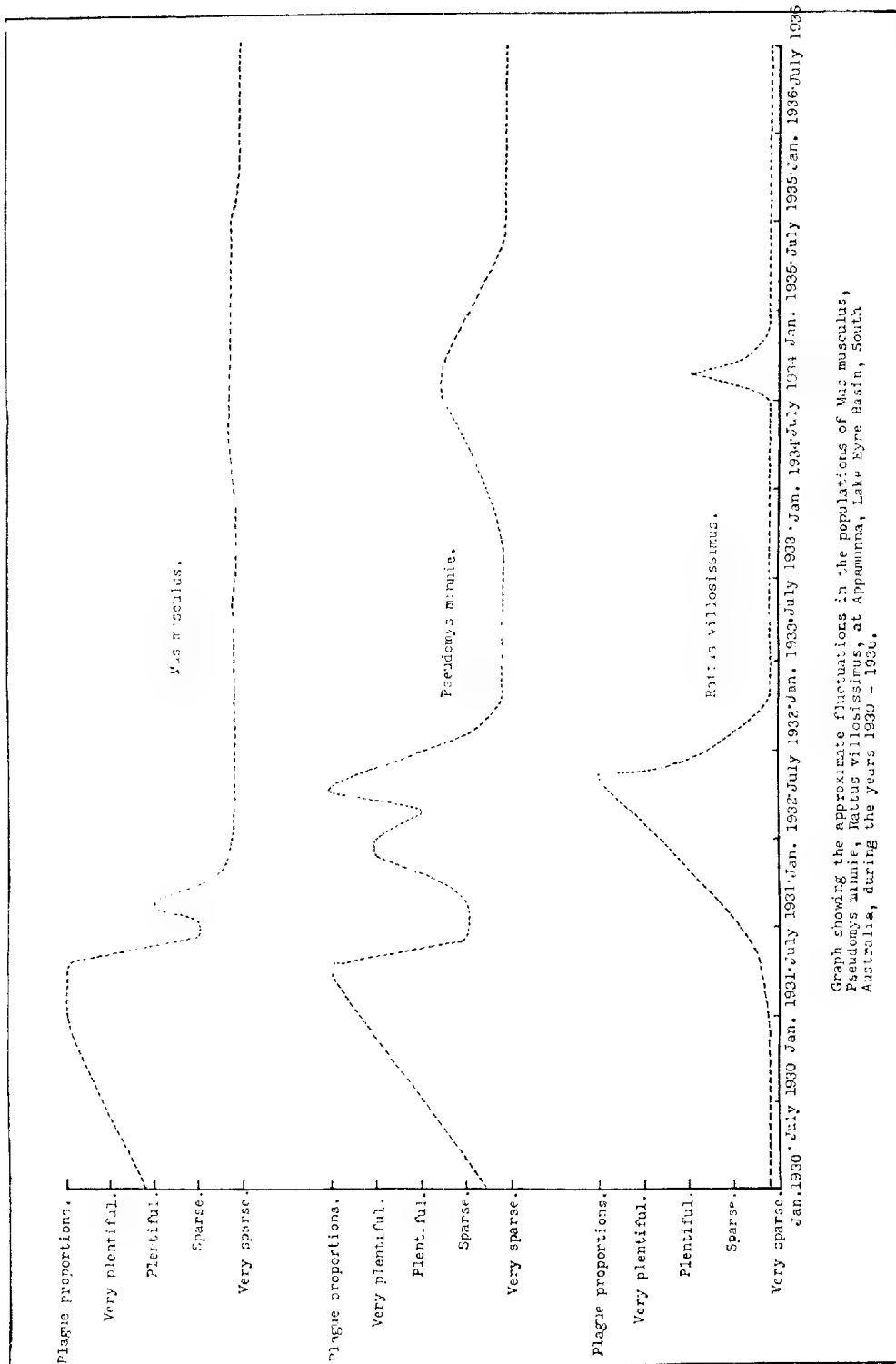
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As indicated in Part IV of this series (2), two species of murids were in process of rapid increase during my stay in the district in December, 1931. The increases culminated some four months later, in one of several peak periods distributed over the years 1930-1936, each one of which might, without exaggeration, be called a plague.

Although this increase was of a phenomenal kind and the aggregate numbers involved were undoubtedly enormous, both fell short of the levels suggested by the accounts of Palmer in 1869, Bagot in 1887, and some others. Without questioning the authenticity of these earlier accounts, a note of caution should be sounded regarding the implications conveyed by such terms as horde and swarm and migration. Too often have these words conjured up a picture of dense masses of rodents moving purposively over the land in plain view, as in the mass migrations of ungulates. Whatever may be the case with diurnal rodents in other parts of the world, such conditions, I doubt, have ever been attained in Australia, and in arid Australia the spectacular element is entirely suppressed by the nocturnal habits of the species concerned. As a general indication of this lack of massed effect it may be mentioned that in December, 1931, in riding on three successive days over a triangular course of 100 miles, three rats were seen; yet at any point on that course they could be trapped in dozens about the camps at night. In interpreting the accounts of most bushmen, moreover, the effect on the imagination of the sudden appearance of considerable numbers of animals, in localities which may normally be almost destitute of vertebrate life, should be taken into consideration.

The proper recording of these rodent increases, and the population movements which follow them, is still to be undertaken. The data can only be placed on a satisfactory basis by a strict statistical treatment by observers resident throughout the whole period of activity and working simultaneously at different points in the affected areas. Separate accounts of observations at isolated points are already available in considerable numbers, but the inferences which can be drawn from them are limited owing to the lack of uniformity in recording and the widely different value of the observations made.

During the period 1930-1936, Mr. Reese has done valuable work by keeping in touch with residents both north and south during the several visitations which have occurred, and his reports to me from Appamunna and Miranda are based partly on the results of trapping and poisoning, and partly on the observations of



reliable blacks in his service, in the surrounding country. During a part of this period Mr. G. Aiston, of Mulka, has also furnished records based upon the takings of blacks, and the combined observations from these and some minor sources now relate to a line through the affected areas of 250 miles north and south. Welcome assistance has come also (through the courtesy of the Beltana Pastoral Co.) from Mr. Shelton at Cordilla, 75 miles south-east of Appamunna. The data is not of a strictly numerical kind, but that from Appamunna gives reliable information on the relative abundance of three discriminated species over a period of six years, and enables several matters, the explanation of which has formerly rested upon conjecture, to be placed upon a basis of fact.

The main points which emerge from a study of the data, which is summarized in the graphs, are as follows.

1. *Frequency of such Increases.*

Although no detailed records are available for earlier occurrences, these are matters of common knowledge amongst the residents and (in recent years) there were well-remembered plagues in the area in 1918 and 1926. There is insufficient evidence at present to indicate a cycle, but the period during which the rat populations were in violent fluctuation, is so considerable a proportion of the whole period which can be reviewed, that rapid change and flux is almost as "normal" a condition as constancy. Clearly, therefore, the populations are at no time strictly comparable in general ecology and bionomics to the permanent sedentary colonies of such coastal rats as *assimilis*, *greyi* and *luticola*, where the amplitude of the increase and reduction movements are never of an extreme kind.⁽¹⁾

2. *The Increases are of two distinct Kinds.*

(a) Those due immediately to local reproduction invariably following increase or rejuvenation of vegetation. These periods cannot always be correlated with local rains, however, since some of the most effective of the rejuvenations are caused by inundation of low-lying areas, from the river channels. The rain causing the fresh may have fallen hundreds of miles away.

(b) Increases due to the arrival of a migration wave. That this term is justified in a general way, and that the individuals composing the wave are actually of distant and not local origin, follows from the extreme suddenness of the arrival in many cases and to the fact that increases have often taken place at times when the local vegetation was at a low ebb and the local murine population almost negligible. Further evidence in support is given by the frequent absence of reproductive activity at such times, and by the wide range of variation in dimensions and structural features shown by the rats, strongly suggestive of an admixture of strains from different districts.

The ultimate origin of all increases of type (b) is, of course, in a local reproductive increase of type (a). During the period under review, it is doubtful whether any of the local increases by reproduction along the 250 m. axis were sufficiently energetic to initiate a wave, the origins of most of which were probably north of Bedourie. A possible exception is the 1930-31 increase of *Pseudomys*

⁽¹⁾ Local "plagues" of *luticola* are known, but they are of a very mild kind. The best examples of which I have personal knowledge were insular.

minnic, which reached enormous proportions in the area about Goyder's Lagoon. Nevertheless, the urge to disperse rather than to concentrate is always operating. Each local increase, unless reinforced by infiltration, rapidly fades away and reaches vanishing point long before the life cycle of any of the three species studied is run. The rapid dissipation of the rats after both types of increase is a highly characteristic feature of the phenomenon, but more especially, of course, when the "peak" has been the result of a migration wave. It is probable that most of the maxima recorded in the graphs were produced by the superposition of a wave upon a period of local increase, but a notable exception is the second peak of the *villosissimus* curve, which occurred at a time when miaroos had been very scarce in the district for 18 months.

3. *The Speed and Direction of the Movements.*

In the literature on rodent plagues in Australia there are several references to rapid movements of large bodies of animals along what appear to have been narrowly restricted routes. These movements do not seem to have been so conditioned by any obvious topographical peculiarity, and the degree of credence to be accorded some of them is doubtful. In the data available for the period and area under review, there is no evidence of such, unless it be on a minor scale, along the river channels, which, of course, necessarily have a strong directing influence on any movement of the kind.

The movements have been comparatively slow, over wide fronts, sometimes of 100 miles or more, and the term migration must be interpreted as a slow diffusive drift rather than as a purposive movement. The major movements, however, have been definitely unidirectional. The approximate direction away from the river channels has been from north to south and by selecting junctures when sudden increases took place successively at distant points, the approximate rate of the movement may be ascertained. In the case of the *villosissimus* wave which arrived at Appamunna at the end of July, 1934, it was of the order of two miles a day.

4. *The Causation of the Drift and the Determination of its Direction.*

This is still one of the most obscure features of such occurrences. The obvious suggestions of a departure from an overstocked and eaten out originating area in search of new and better feeding grounds leaves a great deal unexplained. Such an influence would account for a radial movement of dispersion from a centre, but for a food urge to activate a unidirectional movement one must postulate a maximum of supply in the direction of the movement, and this cannot be shown to be the case in the Lake Eyre Basin. The southerly movement from south-west Queensland, down through the Goyder's Lagoon district towards the Barcoo, took the rats towards country which was usually in poorer condition than that which had been left. In the more remote sense it took them also towards the better favoured coastlands of the south, but the east and north-east coasts were equally attractive and nearer.

The directive influence of water supply has been cited as a possible explanation. In many cases it is open to the same objection as the argument of food

supply and has the further weakness that the indigenous rodents probably do not drink, from necessity at least. During mouse plagues in the south *Mus musculus* is stated to make use of surface waters freely, but I have kept it in captivity (and native species also) in health and vigour, for periods of two years on a diet of grain and tubers, without water. In general the influence of water on the distribution of Australian mammals, particularly in arid districts, has been much overstated. It is probable that all the smaller herbivorous forms are independent of water as such, and even with kangaroos, drinking is in the nature of an indulgence rather than a necessity, in most districts. The case is otherwise with some introduced species.

The influence of topography upon the movement is undoubtedly a potent one. Cleland has shown that in the *Mus musculus* plagues of 1916-1917 topography had a decided effect upon the movements of the mice in New South Wales. In the portion of the Lake Eyre Basin here considered conditions are peculiarly favourable for the exercise of such an influence, since over large areas features of vertical relief in the form of permanent sand-covered loam ridges occur at frequent intervals, and both these and the main river channels are disposed in a north to south or south-westerly direction. The low-lying country, whether flood plains, claypans, or gibber plains, is very generally disposed in the form of corridors between these features, and in many parts of the country these form the obvious routes of travel.⁽²⁾

The influence of such a system upon the mass movements of terrestrial animals upon arrival within its limits can scarcely be doubted. It does not explain, however, the initiation of such a movement in areas where these conditions do not exist, nor does it account for the absence of the opposite south to north movements.

The contra directive effect of winds upon the normal feeding drift of many ungulates is well known and Le Souef (3) suggests it as the determining cause of the first movement of rat swarms. In the Lake Eyre Basin the direction of the prevailing South-East Trade is suitable for such an effect, and it may well be a contributing factor, but it is difficult to accept it as the chief cause.

5. *Specific Differences in the Response to the Increase Stimulus.*

While the times at which population maxima were attained by two or more species frequently correspond, the curves show discrepancies, which on the whole are more significant than the agreements. Thus *Mus musculus*, for example, responded to the stimulus before either of the other two. It was already abnormally plentiful when the records begin in 1930, and it attained the stage at which it could be trapped in hundreds each night four months before *Pseudomys minnie* reached a comparable stage.⁽³⁾ It remained at its first maximum longer

⁽²⁾ The habitual travelling routes of the local blacks are strongly influenced by this natural grain of the country, and they sometimes tolerate great increases of mileage in reaching a destination, rather than take a transverse course to it.

⁽³⁾ These maxima for the three species do not necessarily correspond numerically; the numbers of the two indigenous species were never equal to those of the mice.

than either of the others, and after a partial recovery in August, 1932, declined to a vanishing point, at which it remained, with little alteration for four years.

The two indigenous species differed further from *Mus musculus* in having additional periods of great increase in 1932 and a smaller, but still definite, rise in 1934. The history of the *villosissimus* population is decidedly different from that of its associates in the earlier part of the period, insofar as its first increase is much later and then shows a steady rise without fluctuation to a maximum which corresponds approximately to that of *Pseudomys minnie* in May, 1932. Whereas *Mus musculus* and *Pseudomys minnie* are herbivorous and gramminivorous, *villosissimus* is in part carnivorous, and its population movements towards the end of this phase may have a symbiotic relation to that of the other two. The second correspondence of maxima in 1935 is for the greater part fortuitous, since the *villosissimus* increase is definitely related to a migration wave of short duration, which disappeared at Appamunna before the *Ps. minnie* population.

6. *Reproduction, Sex Ratio, and Causes of Dispersion.*

With regard to the incidence of reproduction and the ratios of the sexes during swarms of murids in Australia, some remarkable statements have been made. The data available for the period reviewed is inadequate for definite statements on either of these points and, moreover, its interpretation is usually complicated by the mingling of migratory and local populations. In the detailed treatment of each species (2), the main facts of reproductive activity which can be deduced from the material actually examined are summarized.⁽⁴⁾

Extraordinary claims have been made from time to time for the numerical preponderance of either sex (3). The evidence on which they rest is unsatisfactory, as personal test has convinced me that comparatively few bushmen can sex rats reliably when the features of scrotum and mammae are not of an obvious kind. The enormous preponderance of males, sometimes to the exclusion of females, which has been asserted, undoubtedly rests on a failure to differentiate between clitoris and prepuce; that is to say, rats that exhibit a protuberant organ in the absence of a scrotum are invariably called young males, whereas a large number of them are undoubtedly females, with occluded vulvae.

The question of the ultimate fate of the swarms is still obscure, so far as recorded observation goes. Evidences of large scale mortality were quite absent in the area during the whole of the period reviewed. No doubt, as suggested, cannibalism plays a part in the latter phases of the occurrences, but it may not be an important part. Loss of the unidirectional urge, dispersion rather than cohesion, starvation and predators, together represent a powerful destructive agency, and if the numbers of the rats are huge, so also is the area of vacant country always ready to absorb them.

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⁽⁴⁾ The datum was inadvertently omitted in the case of *Ps. minnie*; in the series of 78 the ratio was 43 ♂ : 35 ♀.

RECORDS AND DESCRIPTIONS OF MURIDAE FROM OOLDEA, SOUTH AUSTRALIA

By H. H. FINLAYSON

Summary

In the preparation of a series of papers on Central Australian mammals. material derived from adjacent arid and subarid tracts has come up for examination. The species involved are in most cases allied to others occurring in truly Central Australian localities, and the districts yielding them are peripheral to these and present similar ecological conditions. Their inclusion, however, in the main series of papers is inexpedient, and I propose therefore to deal with them separately.

RECORDS AND DESCRIPTIONS OF MURIDAE FROM OOLDEA, SOUTH AUSTRALIA

By H. H. FINLAYSON

[Read 12 October 1939]

PLATES XII AND XIII

In the preparation of a series of papers on Central Australian mammals, material derived from adjacent arid and subarid tracts has come up for examination. The species involved are in most cases allied to others occurring in truly Central Australian localities, and the districts yielding them are peripheral to these and present similar ecological conditions. Their inclusion, however, in the main series of papers is inexpedient, and I propose therefore to deal with them separately.

The most important collection is from the well-known locality Ooldea and its vicinity and the greater part of it has been forwarded by Mrs. Daisy Bates, who has supplemented her noble work on the aborigines of the area by frequent and notable contributions to the knowledge of its Natural History. I take this opportunity of briefly recording my appreciation of her help in working out some of its mammals.

In the Muridae four indigenous species are represented; all constitute new records for the district and two of them are represented by excellent series which have thrown light on the prevailing range of variation, and provided an adequate basis for a detailed restatement of characters. Both are desiderata in the study of many Australian rats.

PSEUDOMYS (PSEUDOMYS) MINNIE Troughton

Four examples of this species occur in the collection. In all characters they are well within the range of variation of the species as it occurs in the Lake Eyre Basin, whence I have recently reviewed a large series (2).

The two freshly-made and unstained skins represent the pinkish, relatively ungrizzled pelage of my Group 2 as there defined.

A male and female taken towards the end of 1931 and alcohol preserved, were both sexually active; the male with large scrotal testes and the female with prominent mammae and pregnant with three 30 mm. embryos.

PSEUDOMYS (PSEUDOMYS) RAWLINNAE Troughton (3)

This species was first described from Rawlinna, 400 miles west of Ooldea, and appears to be known at present only by the two original specimens collected by Mr. A. S. le Souef, one of which was immature.

Thirty-four specimens from Ooldea have been examined, comprising three collections taken in October and December, 1931, and May, 1932, respectively. During this period reproduction appears to have been quiescent, all

females examined having retracted mammary nipples and non-pregnant uteri; the testes of all males, nevertheless, were large and scrotal. The stomach contents consisted of finely comminuted vegetable matter, containing no harsh ligneous fibre nor animal matter, but in several a surprisingly large proportion of sand. A *Laelaps* occurs upon them, but rather sparsely.

External Characters

This rat occurs in the district with *Pseudomys minnie*, to which it bears considerable resemblance in some features, and for convenience in description comparison will frequently be made to that species.

Size small for this group; form stout, short-limbed and thick-bodied. The size of the head in proportion to that of the body is about as in *minnie* (skull length : H. & B. length = 1:3.75), but the head is differently shaped with a shorter more pointed muzzle. Eye from canthus to canthus ca. 7 mm. Ear shorter than in *minnie* and differently shaped, its maximum width nearer the base and the tip more distinctly pointed; its substance pigmented dark at the margins. Mystacial vibrissae as in *minnie*, 35 mm., mostly black, the smaller only white-tipped.

The manus variable but generally very large and stout, particularly in males, and averaging decidedly heavier in both sexes than in *minnie*. In the largest male, length from the base of carpal pads to tip of apicals 11.0 mm., and breadth across base of digits 2.5, 5.5 mm.; in an equally large female the length is the same but the breadth only 4.0 mm. The palmar structures are similar to *minnie* but the pads generally smaller and more prominent and the interspaces more distinct, and there is a greater tendency for the duplication of the fourth interdigital (38%) and inner carpal (34%). The carpals are usually subequal, but, if not, the outer is the larger.

The pes of the same relative length as in *minnie* but much stouter, the ratio breadth to length only 5.1 as against 5.8. The pads are smaller and more prominent, but equally variable though in different directions. Normally the second and third interdigitals are subequal with the first and fourth. The fourth is heeled in 61% and is larger than the first in 76%, subequal in the remainder. The first interdigital is heeled in 74% (21% in *minnie*) and in the remainder is simple. There is great variety in the absolute size of these last two pads and in the degree to which they are elaborated by accessory folds; distinct satellites are occasionally present. The metatarsals are always small, though functional, and they vary much in shape; the anterior is constant throughout the series, but the posterior is absent in 21%. Its position with respect to calcaneum about as in *minnie*.

The tail is variable in length, but is decidedly shorter in relation to the head and body than in *minnie*, the ratio tail: H and B being 1:1.25, as against 1:1.10 in the latter. It terminates similarly.

Scrotum pigmented at free tips only. Spacing of mammae not ascertained; pectorals absent. Sexual differences small.

All flesh dimensions average decidedly lower than those of *Ps. minnie*, but the variation is wide (up to 20%) and in most items there is an overlap.

Pelage

No field-made skins are available, but the following description is drawn up primarily from ten skins made up after two or three weeks in alcohol.

The coat is short and soft but not silky. Mid-dorsally the length varies from 12-16 mm. and is longest in the December batch; the guard hairs, which are not an important element in the coat, reach 20 mm. The basal four-fifths, a dark lead colour (about Ridgway's "Plumbeous Black") succeeded by a pale subterminal band of about 3 mm. of a dull ashy buff (not easily standardized) gradually deepening in tone towards the tips, which, with the long guard hairs, are a cold jet black. The external effect is a fine grizzle of ashy buff and black, drab in tone and at a distance approaching Ridgway's "Saccado's Umber." In a proportion of individuals the subterminal band is yellower than the above (near "Warm Buff" of Ridgway) and the external colour more olivaceous. The dorsal colour is uniform from occiput to tail base, but the facial areas are colder and greyer in tone, though strongly grizzled. The drab tones of the series are quite outside the range of the Lake Eyre Basin *minnie*, but the more olivaceous ones make a distinct approach to the yellow type from the flood plains of the Diamantina.

The belly fur is about 10 mm. long. The basal two-thirds almost as dark as on the back, the distal one-third white or cream (in nature probably white). The dorsal colour fades slowly into the cream of the belly without a decided line of demarcation upon the sides, which are greyish buff with the pink cinnamon tones of the type from Rawlinna, appreciable in two only. The inner marginal aspects of the ear are sparsely covered with greyish white shining hairs; the outer anterior aspect fairly well haired with blackish-brown, sprinkled with silvery-white at the tip; the colour of ear contrasts rather more strongly with the head than in *minnie*. Outer aspects of the forelimb like the sides to within 5 mm. of the carpus, where a conspicuous dark heavily pencilled patch is sometimes developed. Carpus and manus haired with white or buffy white, sometimes very lightly pencilled with dark. Outer aspects of hind limb like the fore; dorsum of foot pure white or buffy white; a calcaneal patch as in *Ps. minnie*, but generally much more marked; frequently jet black and extending further up the leg. Tail pure white below and on the sides, but on its dorsum invariably grizzled to its tip, the admixture of black being very heavy and the upper side strongly and sharply contrasted with the rest.

Skull and Dentition

The skulls of four males and four females, all showing decided wear on M¹, have been examined and measured. In structural characters the skull is close to *Ps. minnie* and exhibits a similar latitude in the range of its variation, both in dimension and form. It averages, however, decidedly smaller and stouter in build, with a shorter muzzle, relatively still larger lacrymals and narrower mesopterygoid fossa. These characters intergrade with *minnie*, but the upper molar row, anterior palatal foramina, and palatal length are all shorter than in that

form and their maximum values fall short, or barely reach, the minimum values for that species. In all other dimensions there is a generous overlap in the range of the two species.

Flesh Dimensions

The following figures derived from 13 males and 8 females, all judged adult, give the range of dimensions and the true means, to the nearest 0.5 mm.

Head and body: ♂ 106-125 (115); ♀ 107-122 (112.5). Tail: 82-98 (91); 86-107 (95). Pes: 24-26.5 (25.5); 24-27 (25). Ear length: 21-23 (21); 20-21.5 (21). Rhinarium to eye: 14-15 (14); 14-14.5 (14). Eye to ear: 9.5-11 (10); 9-10 (9.5).

Skull Dimensions

The following figures give the range and true means (to the nearest 0.1 mm.) of the values derived from four males and four females, all showing decided wear upon M¹:

Greatest length: 29.0-31.2 (30.1); 29.6-31.1 (30.2). Basal length: 24.6-26.9 (25.9); 26.0-26.8 (26.2). Zygomatic breadth: 15.0-16.9 (15.6); 15.6-16.5 (16.0). Braincase breadth: 13.5-14.3 (13.8); 13.9-14.6 (14.3). Inter-orbital breadth: 3.9-4.1 (4.0); 3.9-4.5 (4.1). Nasals length: 11.3-11.7 (11.5); 11.0-11.6 (11.2). Nasals breadth: 3.0-3.3 (3.1); 3.0-3.4 (3.2). Palatal length: 15.1-16.3 (15.6); 15.6-16.6 (16.0). Anterior palatal foramina: 6.6-6.6 (6.6); 6.7-6.9 (6.8). Bulla: 5.0-5.5 (5.2); 4.8-5.4 (5.1). Upper molar series: 5.0-5.2 (5.1); 5.0-5.3 (5.2).

The agreement with the animal from Rawlinna is substantial. In skull dimensions, five of the nine items quoted by Troughton merge in the range for the Ooldea series, and the divergence of the others lies between 1.5-3.0% only; much lower, that is to say, than the prevailing rate of variation. In flesh dimensions three of the values for *rawlinnae* are within the range for the Ooldea rat; the foot measurement exceeds the mean value for Ooldea considerably (27.5 to 25.5) but is only 0.5 mm. longer than the maximum for the present series. Touching the pelage, there is an absence of any reference in the original description to the calcaneal patch and the dark dorsum of the tail, both constant at Ooldea, but until further material from Rawlinna and intermediate localities can be examined, the importance of these discrepancies cannot be assessed and the two may be considered conspecific.

NOTOMYS Lesson

Five species or subspecies of this genus have been recorded from Ooldea. The considerable series here reviewed has been built up by six different collectors since 1926. It is the more astonishing to find, therefore, that none of these five forms are represented in it, though the two species which are, have already received names elsewhere. Even allowing for some uncertainty in identity of kangaroo mice previously recorded, the above circumstance serves to emphasise two factors which are a constant embarrassment in working out the fauna of

sparsely occupied arid districts; namely, the ineffectiveness of desultory collecting in defining the fauna even of restricted localities, and the impermanence and migratory fluctuation over large areas, of a proportion at least of all vertebrate types.

NOTOMYS AISTONI Brazenor

For reasons fully indicated in a recent paper (2), I adopt this name with reservation, as in the present chaos of the genus, it lies under suspicion of synonymy with *N. cervinus* Gould, nec Waite, nec Wood Jones.

Three examples of it are present with the next species in a collection made by Mrs. Bates at Ooldea in October, 1931. In all essentials they are in close agreement with the series from the Lake Eyre Basin recently reviewed (*op. cit.*); two of them represent the pelage type 1, and the other, an aged female in poor coat, a duller colour phase of type 2.

A subadult male with moderately developed scrotal testes is of interest as still showing the flat punctate condition of the presternal gland; the only example possessing this combination of characters, so far examined. The female is pregnant with four large embryos.

NOTOMYS MITCHELLI MACROPUS Thomas

In seven batches of kangaroo mice from Ooldea, taken in 1926, 1931 and 1932, this is the predominating species.

The material examined comprises 50 specimens, all originally alcohol preserved.

Reproduction in general seems to have been inactive; of 14 adult or subadult females examined only three give evidence of any activity; two in July, 1931, being at a very early stage of pregnancy, and one in 1926, lactating. The 1926 batch included also several nestlings and half-grown young. The males of all batches, even the largest, show marked reduction and retraction of the testis. The largest testis found in scrotum is but 8 x 3 mm. (October, 1932), and the largest in the abdominal site 4.5 x 2 mm. (June, 1932). Of the 42 which can be sexed, 28 are ♂ and 14 ♀.

The stomach contents vary from coarsely granular translucent tuberculous material to impalpable white flour; fibrous cellulosic material is generally absent and sand is present in small quantities only. An interesting constituent in many stomachs is a small proportion of chitinous debris of definitely insect origin; the first such occurrence noted in the genus.

A *Laelaps* occurs very plentifully.

External Characters

As compared with *N. "aistoni"* and *N. cervinus* and *N. alexis*, the size is large, the build stout and bulky, and the disproportion of fore and hind limbs distinctly less.

The head is large with a long heavy muzzle region; the rhinarium-eye distance notably longer than the eye-ear distance. The upper lip well developed; sloping

back as in *cervinus* Waite, not pouted as in *aistoni*. Mystacial vibrissae to 57 mm., the postero-superior with their distal one-third white. Supra-orbitals to 30 mm. dark throughout.

Ear: length to 28 mm. In alcoholic specimens the conch and basal parts of pinna are pale but darken evenly and without mottling towards the margins which are deeply pigmented, bluish-black.

The manus is large but tends to be narrow; the mean width across the base of digits 2-5 about as in *aistoni* (to 4 mm.), but the length from base of carpal pad to apical pad a full millimetre greater. The third digit to 4 mm. Both in absolute size and in the proportion and shape of its tactile structures it is decidedly variable and bilateral asymmetry is shown by several examples. The commonest condition of the pad is: Outer carpal > inner carpal > second interdigital > first interdigital = third interdigital, but the interdigitals are frequently subequal and the carpals occasionally so. In all conditions the carpals remain much larger than the interdigitals. The inner carpal is much broadened (though less so than in *aistoni*) and has a partial duplication or accessory fold at its antero-external corner adjacent to the pollex, and sometimes a heel basally. The outer carpal is simple, narrow and longer than the inner. The median (second) interdigital is evenly pyriform, the first and third irregularly oval, but when all three are subequal they tend to a rounder shape. Satellite pads are absent.

The pes large, its length averaging 37 mm. and reaching 40 mm., and the breadth at the base of digits 2-4 across the middle of the pads averages 4.5 mm. and reaches 5 mm. The third digit to 8.5 mm. and the hallux, which is set rather posteriorly, to 3 mm. The undersurface of the digits is lightly haired; more heavily than in *aistoni*, and decidedly less than in *cervinus* of Waite, and the poorly developed apical pads are not covered. The footpads are variable but in general are much as in *cervinus* Waite of the Lake Eyre Basin, third interdigital > second > fourth > 1, but frequently 3 = 2 > 4 = 1, and in a few examples 1 > 4. The hallucal pad is unmistakably present in all 50 examples. The median interdigitals are elongate oval, or slightly constricted towards the middle with a rather sudden expansion at their distal end; their surfaces faintly striate transversely. The first and fourth are low, rounded and smooth surfaced and widely separated antero-posteriorly; the first frequently 5 mm. below the fourth.

The tail decidedly longer than in either *cervinus* of Waite or "*aistoni*"; both mean and maximum value exceeding by a considerable margin the values for these species; the ratio, head and body: tail, is also higher, the values for the three species being, respectively, 1:1.43; 1:1.37; 1:1.39.

The mammary nipples are retracted in most females, but in one moderately prominent set the posterior are 10 mm. from the base of the clitoris, and the anterior are 10 mm. from the posterior; their site is rather well indicated by a narrow zone of white-based hairs. The scrotum is quite undeveloped in the majority of males, but the site of its posterior extremities is faintly indicated by a paired pigment spot.

The condition of the gulo-sternal glandular areas is highly characteristic, and quite different from any phase of that present in "*aistonii*" or *cervinus* of Waite recently reviewed from the Lake Eyre Basin. In all adult or subadult examples of both sexes of more than half-growth the condition is as follows: Externally the area is marked by a tract of specialized hairs, entirely white or cream in colour, conspicuously glistening and strongly adpressed and directed evenly caudad without diversions or opposition ridges. It begins on the mentum at a point 5-7 mm. below the labial margin, covers the greater part of the gular surface and continues with some narrowing to the xiphisternum where it terminates acutely. The shape of the tract in uncontracted material is somewhat hour-glass like, with the constriction presternal, and at this point the tract is divided usually into gular and sternal moities by a very narrow transverse band of the ordinary dark-based ventral fur, though in a proportion of individuals it is continuous. The gular portion is slightly sunken forming a shallow oval basin, variable in size but as much as 16 x 12 mm. The skin hereabouts and on the sternum is flaccid and oedematous. The sternal portion is raised and convex, following the curvature of the thorax, and its hair covering is shorter and denser than on the throat.

The glandular function is evidently more diffused than in either *aistonii* or *cervinus* Waite, and neither on throat nor chest is there a discrete circumscribed gland site, marked off by skin folds, as in those species, though the denser hairing of the sternal patch may indicate some localization of activity. Whether sexual activity influences the external appearance of the gland area, the material does not permit of satisfactory determination. On the whole the sternal hairing is less extensive in females than in males, but the differences are not marked.

In sparsely furred nestlings of H. & B. length 70 mm. ca. the distinctness of the two gland sites is much more marked than in adult and subadults; the two areas which subsequently become densely haired are now almost nude and are separated by a broad band of furred integument.

Pelage

The following description is based upon skins made up from alcohol at once on arrival from Ooldea in June, 1932, after not more than a week's immersion,

Coat long, fine, soft and moderately erect. Mid-dorsally about 16 mm.; the basal two-thirds a rather dark plumbeous, succeeded by a pale subterminal band of about 3 mm. corresponding to Ridgway's "Pinkish Buff," and terminating in a shining black tip. The subterminal band lengthens towards the rump but is obscured by the increasing pencilling of black over the same areas. The general dorsal colour is a sombre olivaceous drab, lighter on the shoulders and fore-back, darker on the midback and rump, and mid-dorsally is between Ridgway's "Olive Brown" and "Hair Brown"; the general dorsal colour quite similar to that of many examples of *Pseudomys razelinnae* of the same area. The mid-ventral fur is about 10 mm. long, the basal half, except on the glandular areas, being a plumbeous shade rather darker than that of the back, and the terminal half snow

white. On the sides the pencilling of black diminishes towards the belly and the increasingly conspicuous subterminal band becomes richer in colour, until at its junction with the ventral white it is an undiluted cinnamon buff. The dorsum of the head is like the foreback, except that the muzzle is greyer; the upper lip and a small area of the cheek are white, the rest of the facial area merging into that of the crown and sides.

In the ear, the greater part of the pinna externally is well haired with blackish-brown, sharply contrasted with the grizzled bases and the rest of the dorsum, while internally the hairing is thinner, largely marginal and greyish-white. The hairing of the limbs externally and internally follows that of the sides and ventrum, respectively; the carpus, manus and pes are pure white, except that at the outer aspect of the heel in the latter there is an ill-defined blackish patch. The tail is well haired on all surfaces except at the base proximally. Dorsally it is blackish-brown (varying from Bistre to almost Black), the sides and ventrum pure white. The tail hairs become noticeably erect at about the mid-point of its length and gradually lengthen distally to form a profuse brush 16-18 mm. long; the colour separation is sharply maintained throughout the entire length of the tail.

Individual variation in pelage characters is apparently slight, but cannot be satisfactorily defined with the available material since the bulk of it has obviously suffered through alcohol preservation. This has led in the majority of cases to the development of a decided but variable ferruginous tone in the coat, both terminally and in the underfur, which is quite absent in fresh skins. Variation from seasonal, sexual and age causes appears to be very slight.

The dimensions of the series selected as being free from obvious immaturity show considerable variation, particularly notable in material culled from a very restricted area; the head and body length varies by 13%, and that of the tail by 18%. The sexes are virtually identical.

Skull and Dentition

Twenty-four examined and measured, of which 14 are males, 10 females; the series includes numerous growth stages.

Size large, but comparatively narrow in the posterior zygomatic width and in braincase; the muzzle region long and generally heavy, but decidedly variable in these respects even in fully adult skulls, particularly in width of muzzle and shape of nasals. Typically the contact of the nasals with the frontals is narrow and there is a tendency for a sudden increase in width of the distal one-third, diminishing again towards the apex. The posterior zygomatic width exceeds the anterior, but the difference is not marked. The anterior margin of the zygomatic plate with the base thrown well forward of the upper spur, which is well developed, but the degree of concavity variable. Anterior palatal foramina generally reaching but slightly beyond the anterior margin of M^1 , never to the lingual cusp;

width 1.6-2.0. Mesopteryoid fossa varying in width by 70% in otherwise comparable skulls; bullae relatively small. The incisor index fairly constant at about 60° .⁽¹⁾ An anterior accessory cingular cusp is present on the upper M^1 in four examples; it is developed on the same site and to about the same degree as in *N. cervinus* of Waite *et al.* (2).

Flesh Dimensions

The following figures give the range and true mean (in brackets) for 20 adult males and 6 adult females (to the nearest 0.5 mm.):

Head and body: 100-113 (106); 101-118 (108). Tail: 140-172 (155); 140-166 (150). Pes. length: 36-39 (37); 36-40 (37). Pes. breadth:⁽²⁾ 4.5 (4.5); 4.5 (4.5). Manus. length:⁽³⁾ 8.9 (8.5); 8.9 (8.5). Manus. breadth:⁽⁴⁾ 3.5-4 (4); 3.5-4 (4). Ear: 24-28 (25.5); 24-26 (25).

Skull Dimensions

The following figures give the range of dimensions and true mean (in brackets) for 7 males and 5 females, all free from obvious immaturity in external characters and with marked molar wear (to the nearest 0.1 mm.):

Greatest length: 31.4-33.2 (32.4); 31.0-33.0 (32.0). Basal length: 25.5-26.8 (26.2); 25.5-26.9 (26.1). Zygomatic breadth, post.: 15.3-16.3 (16.0); 15.7-16.3 (16.1). Braincase, breadth: 14.5-15.5 (14.9); 14.5-15.1 (14.8). Interorbital breadth: 5.2-5.8 (5.6); 5.2-5.6 (5.4). Nasals length: 11.6-12.8 (12.1); 11.6-12.7 (12.3). Nasals breadth: 3.1-3.2 (3.2); 3.0-3.3 (3.1). Palatal length: 16.0-17.5 (17.0); 15.8-17.3 (16.7). Ant. palatal foramina, length: 5.8-6.1 (6.0); 5.6-6.0 (5.8). Ant. palatal foramina, breadth: 1.7-1.9 (1.8); 1.6-2.0 (1.7). Bulla: 5.1-5.9 (5.5); 5.2-5.9 (5.6). Upper molar series: 5.0-5.4 (5.2); 5.0-5.4 (5.2). Incisive index: 60° - 62° (60°); 59° - 60° (60°).

In using the name *N. mitchelli macropus* for the kangaroo mouse here reviewed, I do so fully aware that on a basis of published data, a moderately good case can be made out for its sub-specific alliance with *N. gouldi* of South West Australia; and the existence of the Western Australia derived *Ps. raeclirnae* at Ooldea gives some colour, on the grounds of distribution, to such a view. My reasons for taking the first course are briefly as follows:

1. Three specimens of *Notomys* from Coomandook, Gurrai, and Peake in the South Australian mallee districts are in complete agreement in external characters and pelage with the Ooldea series; the correspondence extending to the critical characters of the gulosternal area. The skulls are in general agreement also, and the dimensions for the mallee skulls all fall within the range at Ooldea.

⁽¹⁾ But is evidently subject to occasional marked aberration; a single skull (not tabulated) with imperfect data but almost certainly conspecific with this series, gives 52° .

⁽²⁾ At base of digits 2-4 across middle of pads (the maximum breadth of sole).

⁽³⁾ At base of digits 2-5 (maximum width of palm).

⁽⁴⁾ From base of the outer carpal to extremity of the apical pads.

except for the zygomatic breadth which is higher and the interorbital width which is lower, the deviation being of the order of 2% only.

These mallee specimens are more nearly topotypical of *N. mitchelli macropus* than is the Victorian specimen of Brazenor, which differs in its less yellow colour and paler ear backs.

2 According to Thomas and Gould himself (in emendation), the basis of *N. gouldi* Gould is apparently the specimen from South-west Western Australia figured by Gould (Mammals of Australia, pl. ix) as *Hapalotis mitchelli*. This plate shows pelage characters very close to my Ooldea and Mallee series and Gould states positively that there is an area of specialized hairs on throat and chest, indicating a continuous, or scarcely interrupted gulösternal tract as in the material here reviewed. Gould further states, however, that this Western Australia animal occurred also in South Australia, instancing the identity of an example sent by Dr. Harvey to London from the latter State.⁽⁵⁾ On the basis of Gould's writings alone, therefore, one would have little hesitation in using the name *gouldi* for the Ooldea animal, and this would necessitate an extension of range of *gouldi* almost to the Victorian border.

3 In 1921 O. Thomas, having a large series of recently collected *gouldi* from Western Australia, separated Dr. Harvey's specimen from them as the type of *N. mitchelli macropus*, and however slightly the distinctions between the two have been indicated, one can hardly doubt that they were real.

4 The recent review of the characters of "*gouldi*" by Brazenor has further complicated the matter, as the animal he describes is evidently different from the series collected by Shortridge and similarly named by Thomas. Its larger size and some other characters suggest that it consists partly at least of *macrotis*, and that the wider anterior palatal foramina claimed for the latter by Thomas is an aberration.

Finally, it may be noted that two specimens of *N. gouldi* from Dwaladine in South-west Western Australia, kindly lent me by Mr. Glauert, while too immature for definite conclusions to be made, favour the identification adopted here.

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⁽⁵⁾ Either Port Lincoln or Kangaroo Island, more probably the former.

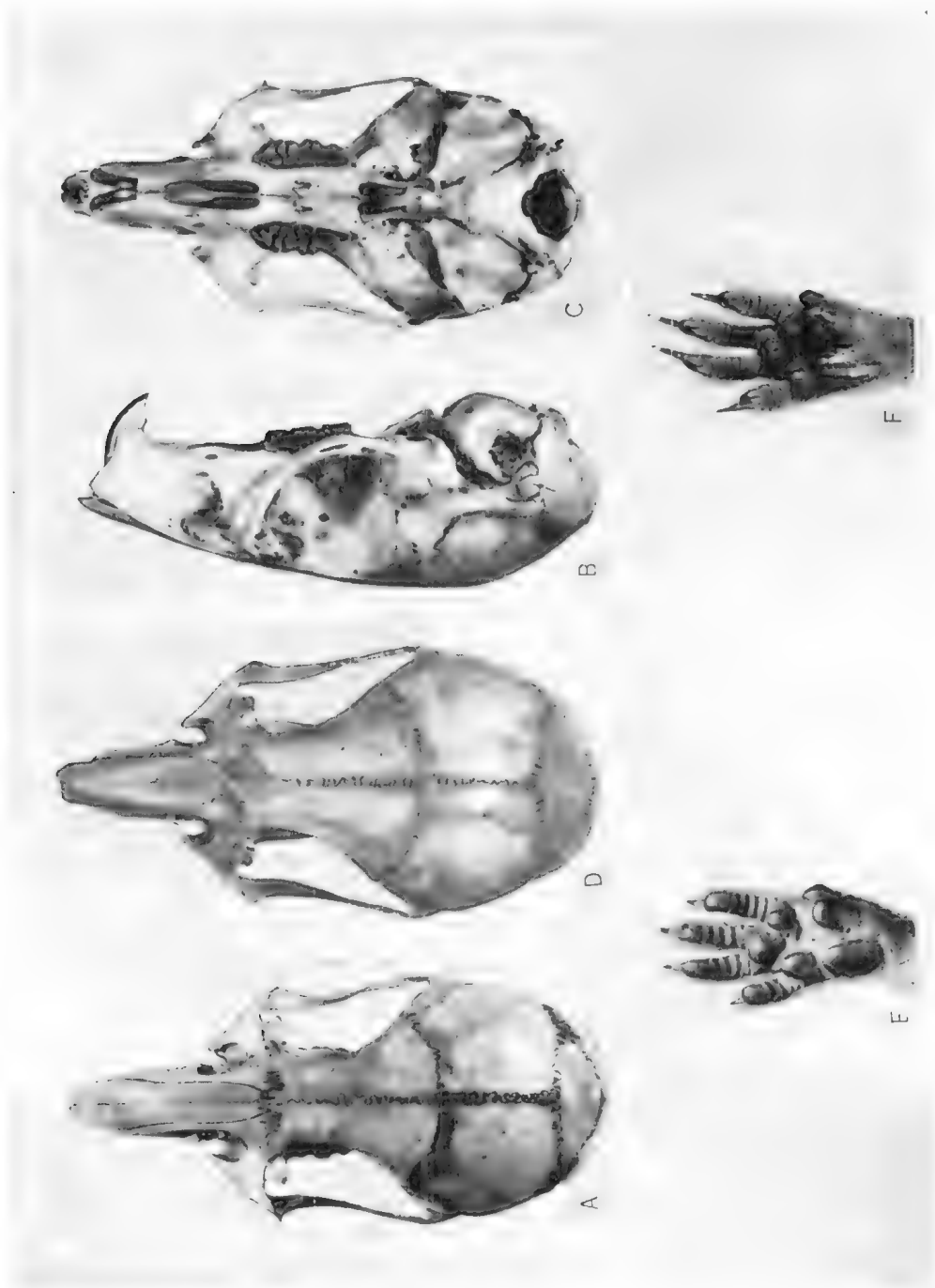
EXPLANATION OF PLATES XII AND XIII

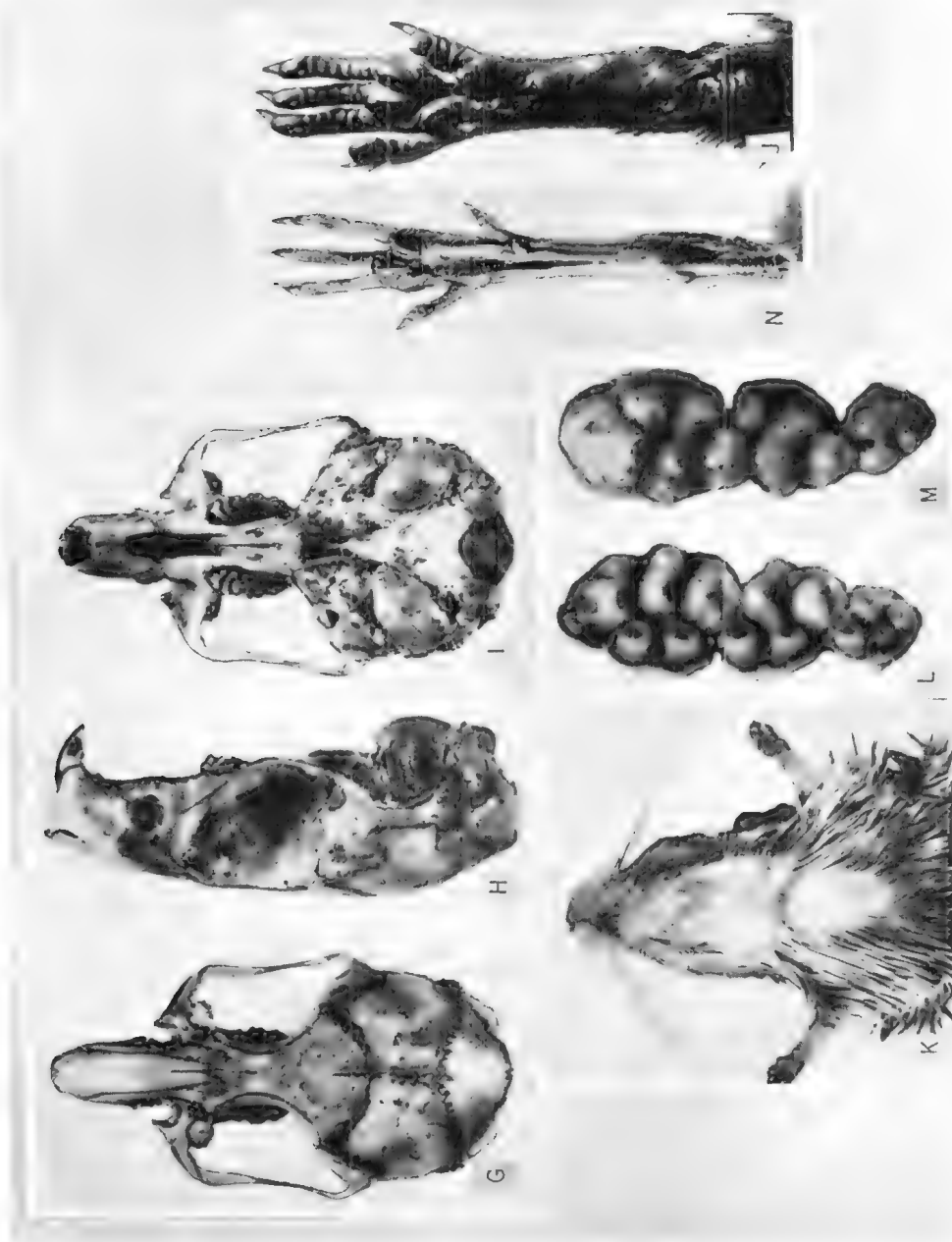
PLATE XII

- Figs. A, B, C. Aspects of the skull of an adult ♂ of *Notomys mitchelli macropus*. Thomas. x 2.2 ca.
- Fig. D. Dorsal aspect of the skull of a subadult ♀ of *N. mitchelli macropus* of about two-thirds body growth, to show disparity with A in the development of muzzle region. x 2.4 ca.
- Fig. E. Right manus of an adult ♂ of *Pseudomys rzelinnæ* Troughton (var.?). Ex alcohol. x 3 ca.
- Fig. F. Right manus of an adult ♀ of *Notomys mitchelli macropus*. Ex alcohol. x 3 ca.

PLATE XIII

- Figs. G, H, I. Aspects of the skull of an adult ♂ of *Pseudomys rzelinnæ* Troughton (var.?). x 2.0 ca.
- Fig. J. Right pes of an adult ♂ of *Pseudomys rzelinnæ* Troughton (var.?). x 2 ca.
- Fig. K. The gulosternal area in an adult ♂ of *Notomys mitchelli macropus* Thomas, to show the general external appearance of the gland sites. The gular and sternal planes are parallel, with the former considerably below the latter. Ex alcohol. x 1 ca.
- Fig. L. Worn right upper molars of an adult ♂ of *Notomys mitchelli macropus* Thomas, showing a well-developed accessory cingular cusp on M¹. x 9 ca.
- Fig. M. Scarcely worn right upper molars of a subadult ♀ of *N. mitchelli macropus* Thomas. x 9.5 ca.
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ABORIGINAL DECORATIVE ART FROM ARNHEM LAND, NORTHERN TERRITORY OF AUSTRALIA

By C. P. MOUNTFORD, Honorary Assistant in Ethnology, South Australian Museum

Summary

This paper describes a series of aboriginal paintings from Arnhem Land. Those on bark, with the exception of D, pi. xvii, which Dr. D. R. Brown obtained at Groote Eylandt, were collected from Gouldburn Island by Miss M. Mathews. The decorated wooden slab was secured from Groote Eylandt by Mr. N. B. Tindale, and the painted stone from Millingimbi by Mr. H. Shepherdson.

**ABORIGINAL DECORATIVE ART FROM ARNHAM LAND,
NORTHERN TERRITORY OF AUSTRALIA**

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PLATES XIV TO XVIII

[Read 12 October 1939]

This paper describes a series of aboriginal paintings from Arnhem Land. Those on bark, with the exception of D, pl. xvii, which Dr. D. R. Brown obtained at Groote Eylandt, were collected from Goulburn Island by Miss M. Mathews. The decorated wooden slab was secured from Groote Eylandt by Mr. N. B. Tindale, and the painted stone from Millingimbi by Mr. H. Shepherdson.

It would appear that this type of art is confined to Arnhem Land, for neither Roth (1902, figs. 79-93) when writing of the cave paintings of north-west central Queensland, nor Hale and Tindale (1924, p. 153) who studied the art of Princess Charlotte Bay, Queensland, made any reference to paintings on bark, although the latter authors figured a fragment of turtle bone on which a man had been depicted, as well as several groups of rock paintings. Similarly, the present author found no trace of bark paintings of the Arnhem Land type among the aborigines of Port Darwin.

The paintings described in this paper are typical of Arnhem Land, and in the main picture the animals, birds, fish and plants that the aborigine meets in his every-day life, although several totemic designs are included in the series. Yellow, red, black, and white pigments have been used in the various designs in the form of lines and dots on a background of uniform colour. No attempt has been made to shade one pigment into another, although the three latter have often been combined to produce varying shades of red and brown.⁽¹⁾ The paintings have been executed on the inner surfaces of sheets of bark, averaging 50 cm. in length, that have been stripped from the trees and straightened out while green. The walls and roof of the wet weather shelters of the aborigines of Arnhem Land are made from similar sheets and form excellent drawing boards on which the native artist can exercise his talent during the enforced leisure of the rainy season. Tindale (1925, p. 117), who noticed this characteristic among the natives of Groote Island, writes: "Any bark hut that had been occupied for any length of time contained such pictures."

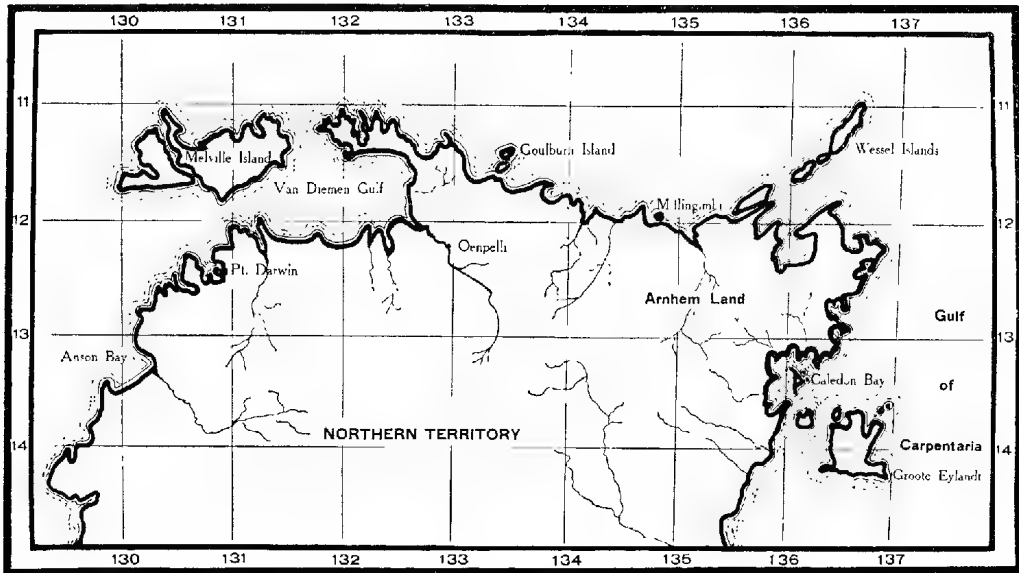
⁽¹⁾ Tindale, 1925, p. 117, mentions that the Groote Islanders also increased their range of colours by mixing the various pigments.

DESCRIPTION

PLATE XIV

A, executed in black and yellow lines and dots on a white ground, is a fair representation of one of the large lizards, probably *Larus gouldii*. The forked tongue, double penes and correct number of digits are indicated.

B is an excellent drawing of the spiny ant-eater (*Echidna aculeata*). The upper part of the body is covered with parallel lines of black, red and white, the lower half with red and white lines intersected with yellow and black dots. The spiny covering extends only over the body and tail (as in the living animal). In the painting the enlarged claw of the hind feet of the creature is wrongly shown as the first digit on both hind and on one fore foot; the number of digits is also incorrect. Both eyes are indicated, whereas in a lateral view only one would be visible ⁽²⁾. The forked tongue projects from the tiny mouth, whilst below is a partly erased image of the same organ. A comparison of this painting with that on C, pl. xvii, shows that, in the latter example, the design is more conventionalized, therefore less attention has been paid to detail.



C, produced in red pigment on a white ground, represents a kangaroo, or allied marsupial, with its young in the pouch. Both eyes are indicated (as in B, pl. XIV) and the tail bent upward to fit the space available on the sheet of bark. The body is covered with a chevron pattern, the head and tail with dots. An examination of many of the drawings of animals and birds in this series suggests

⁽²⁾ This is a common characteristic in the primitive art of Northern Australia. While working with the Walpari tribe of north-western Central Australia one of the natives made quite a creditable drawing, in side elevation, of our motor vehicle, except that whereas two wheels were shown in the correct position, the others were drawn as circles above the vehicle.

that they were painted from dead models (see B, D, and F, pl. xvi), but the kangaroo in this example, although the legs are placed too far forward, is depicted as alive and hopping.

D is an ingenious painting of a yam. It shows not only the tubers beneath, but the vines above the ground. The tubers are executed in yellow, black and white lines on a red ground, and the vines and leaves in white. Small leaves are drawn on the crown of the tuber, and, as arrow heads, on the vines.

E and F show a slab of ironwood, collected at Groote Eylandt by Tindale (1925, p. 133), on which are paintings in yellow, red and white. E represents a lizard, and F one of the sea-going turtles. Spencer (1914, pl. iv) illustrates three painted wooden objects, associated with the Muraian ceremonies of the Kadadu and adjacent tribes. It is possible that E and F may have a similar significance to these.

PLATE XV

A, painted in yellow and white on a brown ground, is possibly a sword-fish (*Niphius gladius*), although no fins are delineated.

D is a much better representation of this fish, in which a number of ribs and the backbone are portrayed by means of red lines dotted with white. Remarkable attention to detail is evident in the picturing of the four parasites on the right-hand side of the body. These were identified by Mr. H. M. Hale as Cymothoid parasites of the order Isopoda. The design, upper right, is possibly one of the "leather jackets" (probably *Cantherines* sp.).

B—in red on a white ground— shows the fin arrangement and upturned mouth of the much-dreaded stone fish (*Synanceia* sp.). This fish inhabits the coral reefs of the Queensland and northern coasts of Australia, and is capable of inflicting a dangerous, often fatal wound to any barefooted person who may tread on it. Here again two eyes are indicated, as well as the backbone and some of the internal organs.

C is, in all probability, the well-known Mulloway or Butterfish (*Sciaen* sp.). The position of the spinal, ventral and dorsal fins, the shape of the tail, and the projecting lower jaw, indicate that the aborigine pays more attention to detail than is usually credited to him. (See also D, pl. xv.) The pattern of red lines on a white ground, with occasional areas in black, gives a pleasing and harmonious result, both in arrangement of line, mass and colour.

E, somewhat crudely painted in red on white ground, depicts the sea-going crocodile (*Crocodilus porosus*). The distortion of the design to fit a circumscribed area is a characteristic often seen in these bark paintings.

F, in red and white lines on a yellow ground, is a painting of a saw fish (*Pistus zysron*). Although this example is more diagrammatic than is usual, the saw, fins and tail are sufficiently well placed as to make a tentative identification possible.

PLATE XVI

A, with D, pl. xiv, and C and D, pl. xviii, illustrate different species of tubers and yams. The first-named is executed in a more extensive range of colours than usual. The lower line of tubers is painted in dark brown; the next in light red with white spots; the third in dark red with yellow spots; and the uppermost line in light red with yellow spots. The parallel horizontal lines near the top of the sheet represent the ground, above which the young shoots of the yams are shown in various stages of growth. The shoot on the extreme left has already developed leaves, the next three have not reached that stage, while the one on the extreme right has met an obstruction which has forced it to grow parallel to the surface.

B, in black on a white ground, is a particularly decorative painting of a male kangaroo. The anatomical detail, such as the eyes, ribs, heart, lungs, stomach and liver are painted in white, and sometimes spotted with red. The combination of chevrons, parallel lines and dots makes this sheet of bark one of the most attractive in the series.

C suggests one of the small land lizards, but the details are insufficient for identification. The colours utilized are red, black and white.

D, on account of the black head, the shape of the beak, and the association of the long necked fresh water turtle, suggests the jabiru (*Xenorhynchus asiaticus*). The legs of the bird are distorted to fit the narrow sheet, while the alimentary canal, gizzard, and only one eye, are indicated. The bird is drawn as if lying dead.

E is a representation of one of the large lizards, in which little anatomical detail is present, except the forked tongue and the double penes. The latter are shown as club-shaped projections at the base of the hind legs. (See also A, pl. xiv.)

F is painted in black and red lines on a white ground. The curving beak, and the shape of the head, resembles those of a brolga (*Megalornis rubicundus*). As in the case of the jabiru the bird is drawn as if dead, and the eye, gizzard, and alimentary canal only are shown.

PLATE XVII

A illustrates a living emu on which the spinal column, alimentary canal and gizzard are indicated.

B, in red lines on a white ground, pictures a crocodile with the snout shortened and bent slightly to fit the bark sheet.

C, in yellow and red on a white ground, is a somewhat conventionalized drawing of a spiny ant-eater. Quills outline the whole design, while the body is filled in with a geometrical pattern. A comparison between this drawing and that on B, pl. xiv, indicates how, even in the same locality, an animal may be depicted in a widely differing manner.

D is a painting on a stone from Millingimbi, Crocodile Island, and represents the head of *Crocodilus porosus*. This specimen, which is decorated in red and black with white dots, is 31 cm. in length. The people of the Kadadu tribe, of the east Alligator River, paint stones in a similar manner. Spencer (1914, p. 224) illustrates a number of these stones, and gives the following description: "They are, all of them, naturally-shaped stones, for the most part, apparently sand stone. They all resemble objects such as yams, to which they approximate in shape, or the eggs of different animals. In most cases the stones seem to have been rubbed over, first with red ochre, in a very few yellow ochre had been used, and ----- white cross lines, and dots have been added." Such stones are associated with the Muraian initiation ceremony. It is likely that the Millingimbi example has a similar significance, belonging, as it does, to an adjacent area. Mountford (1929, p. 245) describes a rock carving from Panaramittee, South Australia, in which the head of *C. porosus* had been engraved with considerable accuracy.

E, in red and white lines on a yellow ground, is a remarkable painting from Groote Eylandt of a sailing canoe, similar to those in use in that locality. Tindale (1925, p. 111) figures this type of canoe, which varies from eighteen to twenty-five feet in length. The sail of each vessel is supported on two long slender spars up to seventeen feet in length. In the present painting the thicker lines represent the ropes, and the more indefinite the mast. While the shape of the sail and the number of ropes agree with Tindale's description, the placing of those ropes differs in several respects. Four men are paddling the canoe with decorated oars, a characteristic also recorded by Tindale (1915, pl. xii). On the same sheet are drawings of a number of animals and birds. The lower right and middle left are probably dugongs (*Halicore dugong*), and the lower left a sea turtle; the upper left may be either a lizard or a crocodile, but the birds are not identifiable. This painting was collected by Dr. D. R. Brown.

G is an unusual painting of a number of large fruit-eating bats, hanging head downward from branches. The painting is in yellow and red on a white ground. These creatures gather in large flocks in the mangrove swamps of the northern coast of Australia, and form a considerable source of food supply for the aborigines. In general, however, the eating of this meat is an old man's privilege. The extensive wings of the bat are indicated only by a small curving line from each shoulder, but the large ears, fox-like head (from which the bat receives the common name of "flying fox") and the genitalia are plainly shown. The patterns on the body of each bat are of more than usual interest, but whether they are employed as a means of distinguishing different species, or purely an artist's dislike for repetition of the same decorative scheme, is unknown.

PLATE XVIII

With the exception of C and D, which are plant motifs, these paintings are conventional designs, which appear to have been derived from fish or reptilian

form. Two, B and F, are known to be *Mardai'in* totem designs,⁽³⁾ G is a *Marai'in* design, and it is likely that A and H are similar in meaning.

A, painted in lines of yellow, red and white dots, on a dark brown ground, may have been derived from a fish motif. The head and eyes are duplicated on either end as well as the V shaped lines which probably represent ribs similar to those drawn on E, pl. xv.

B is a representation of a *Mardai'in* totem stone. A comparison of this painting with that on A, pl. xviii, would suggest that this design also had its origin in some fish-like form.

C is a naturalistic picture of a yam, which bears a close resemblance to that illustrated on D, pl. xiv.

D, in white lines on a dark brown ground, represents a different type of tuber. At the crown of the yam are depicted short leaves and trailing vines, while the projections at the bottom are either badly drawn, or perhaps specialized roots.

E, F, G and H are four bark drawings that indicate how a naturalistic reptilian motif can, by the process of conventionalisation, reach a stage where the source is not evident.

E figures one of the larger lizards (probably, *V. gouldii*). In F the lizard shape is still recognisable, although the head, tail and legs have been shortened. In G the head, legs and tail are still evident, while in H the conventionalisation has reached a stage when, without reference to the intermediates, the reptilian source is not recognisable.

G and H are *marai'in* designs from Goulbourn Island.

DISCUSSION

The bark paintings described in this paper are, with the exception of E, pl. xvii, the work of the Man tribe, who live on the mainland opposite Goulburn Island. Few details were obtained by Miss Mathews at the time they were collected, but for the most part they portray animals, birds, fish and reptiles so well drawn that tentative identification is possible.

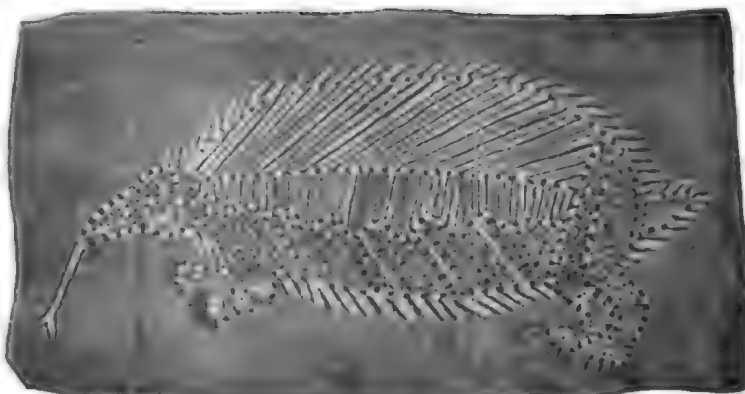
The designs and the combinations of the pigments on the majority of the sheets are both pleasing and harmonious. Unfortunately, the high cost of printing prevents their reproduction in natural colours.

In the majority of paintings under review, both external details and internal organs are indicated. As far as the writer is aware this is a unique phase of primitive art, both in Australia and elsewhere.

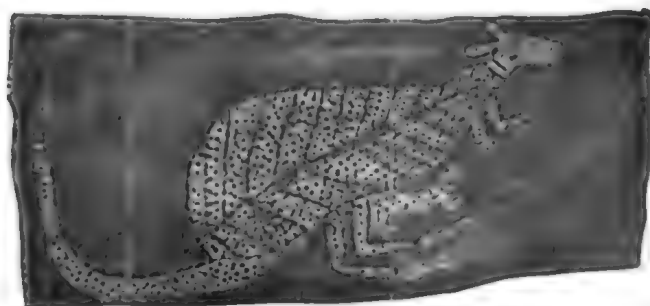
⁽³⁾ Thompson (1939, p. 290) records that similar designs are painted on the bodies of initiates during *mardai'in* initiation ceremonies. The designs usually relate to a rock or waterhole that was created when one or the other of the totemic ancestors sank into the ground. Thompson's name *mardai'in* and Spencer's *marai'in* both occur in Goulburn Island in connection with the bark drawings. Such designs in the latter locality, no doubt, refer to a similar group of rituals to those recorded by both Spencer and Thompson.



A



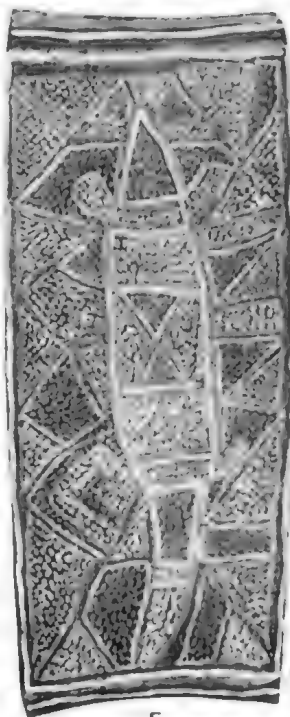
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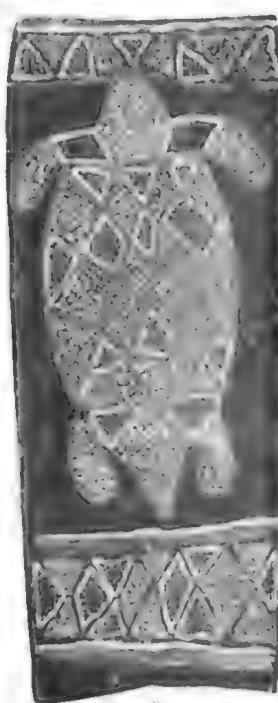
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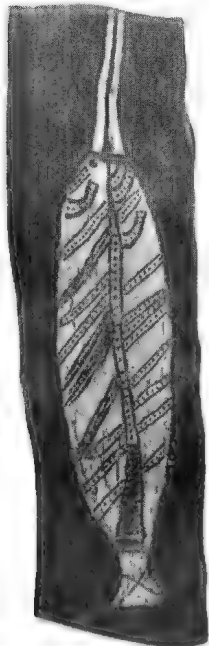
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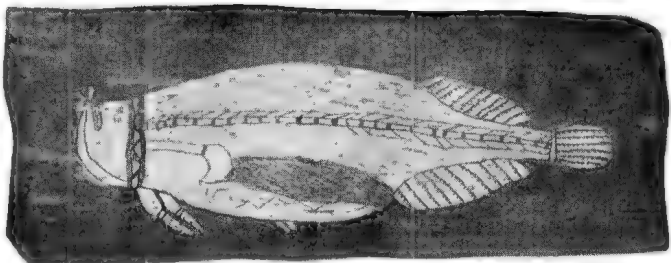
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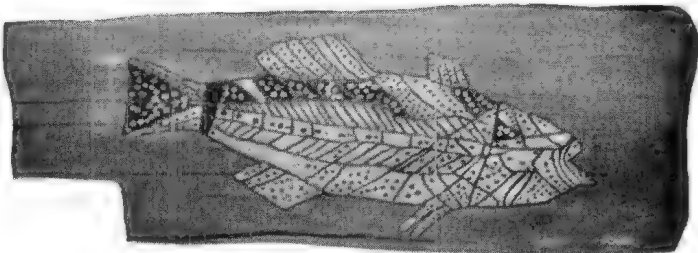
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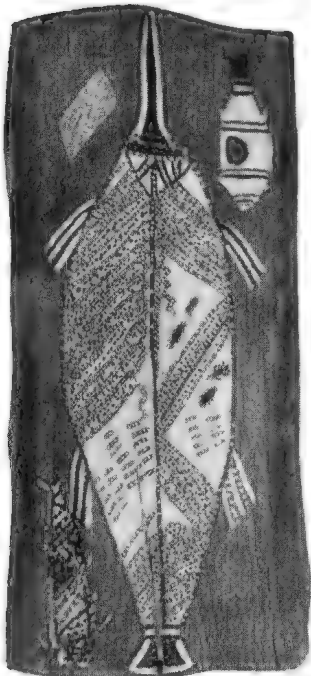
A



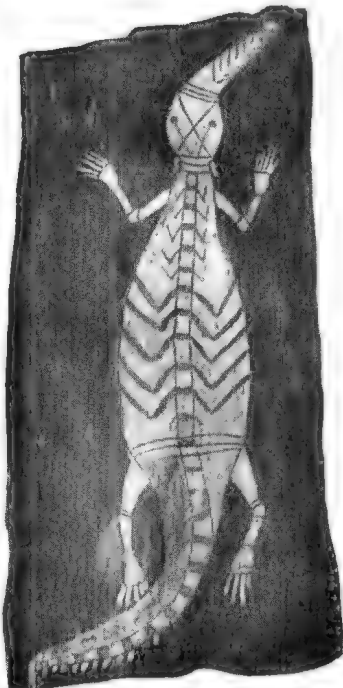
B



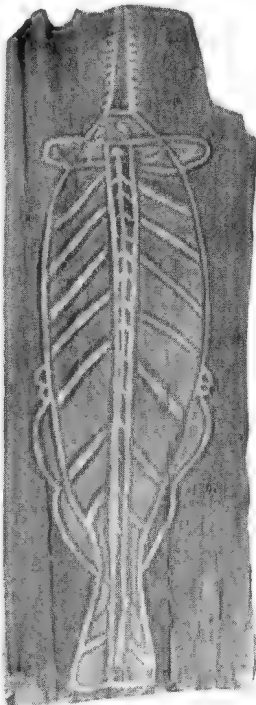
C



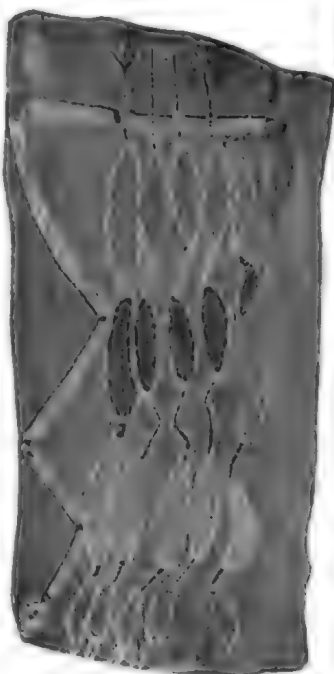
D



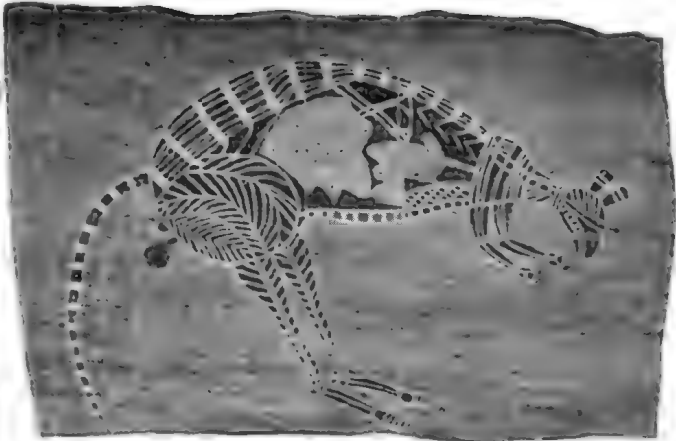
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F



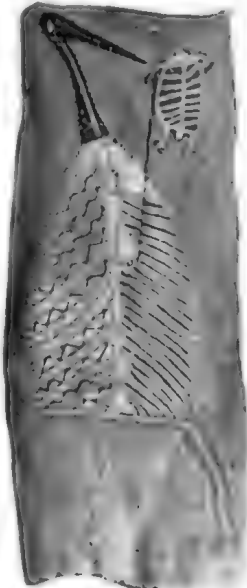
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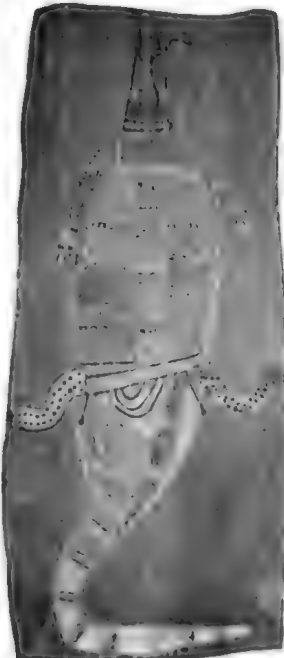
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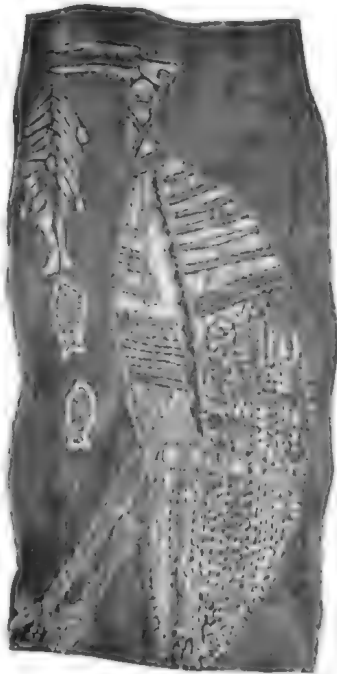
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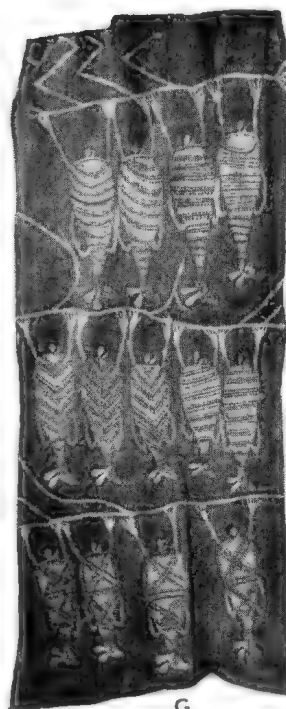
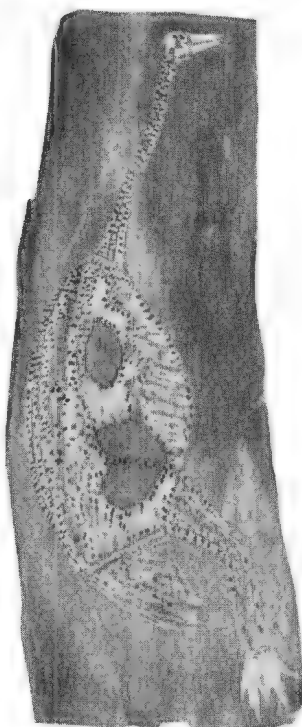
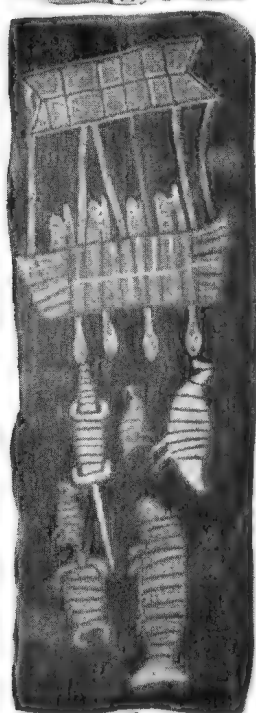
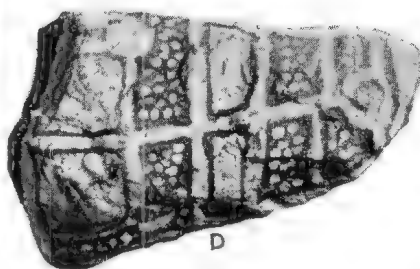
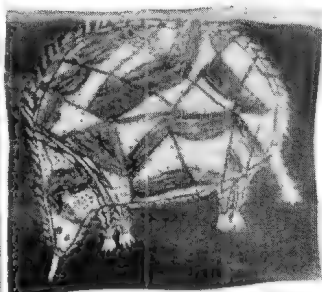
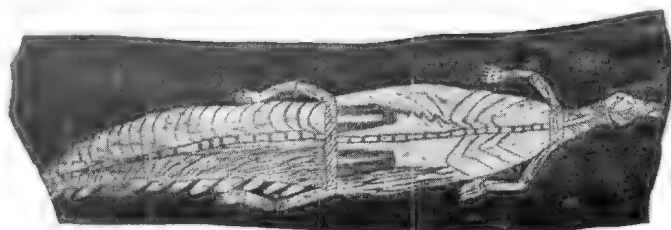
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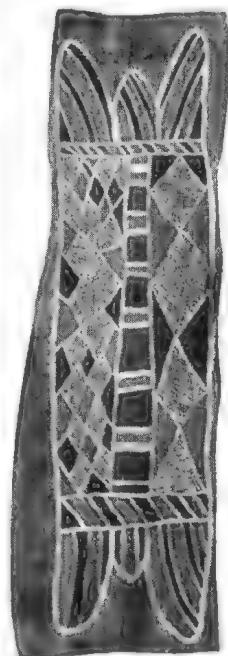
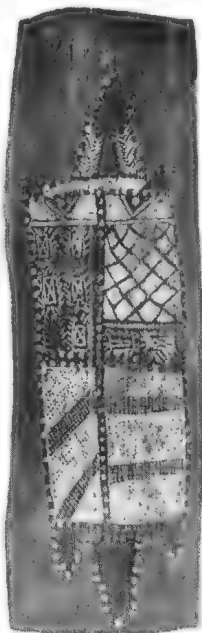
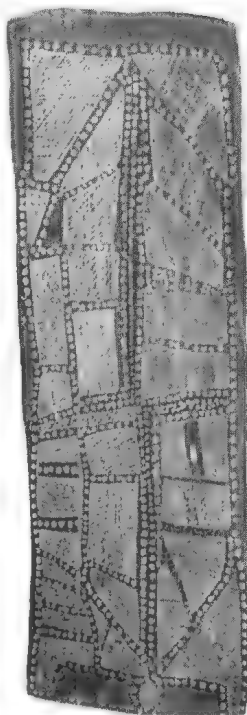
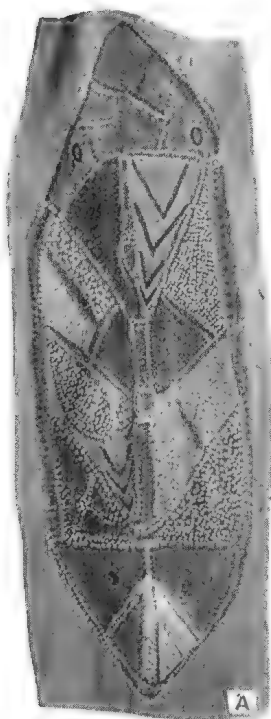


E



F





The attention to detail displayed by some of the artists is also noteworthy: *i.e.*, the claws and spines of the echidna, B, pl. xiv; the parasites on the sword fish, D, pl. xv; the leaves and vines of the yam, D, pl. xiv, A, pl. xvi, C, pl. xviii, and D, pl. xviii; as well as the internal organs of the various animals and birds, particularly the kangaroos, B, pl. xvi. Nevertheless, curious mistakes have crept in, *i.e.*, the large claws of the echidna, B, pl. xiv; the showing of both eyes, when only one should be visible; and the fact that in the majority of cases the number of digits on both the animals and reptiles is incorrect, though similar inaccuracies do not apply to the birds. This error may be due to the inability of aborigines to count definite numbers past four.

It has already been pointed out that several of the animals have been painted as if lying dead, *i.e.*: the emu, F, pl. xvii; jabiru, D, pl. xvi; brogla, F, pl. xvi; and kangaroo, B, pl. xvi; such, however, is not universal. The echidna, B, pl. xiv; the kangaroo, C, pl. xiv; and the emu, A, pl. xvii, depict living models.

Apart from the much feared stone fish, B, pl. xv, all the animals, birds, reptiles and plants are used by the aborigines as food, and with the exception of the ceremonial designs on pl. xviii, are more or less identifiable. This naturalism is in contrast to the art of the Melville Islanders, whose designs are, almost without exception, conventional (Spencer, 1914, p. 421). When compared with the art of the Central Australians the difference is even greater. Mountford (1937, p. 21) points out that "By far the greatest number of designs are so highly conventionalized, as to be indecipherable without the aid of the artist who produced them."

The gradual development of a naturalistic motif to one of an abstract form is well illustrated on pl. xviii, while the association of such abstract designs with the ceremonial life of the tribe is worthy of much fuller investigation.

SUMMARY

This paper records thirty bark paintings, a painted wooden slab and a stone, the work of the natives of Arnhem Land. Each example is described and the technique, symbolism and distribution is discussed. Relevant literature is also quoted.

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ATMOSPHERIC POLLEN IN THE CITY OF ADELAIDE AND ENVIRONS

By F. V. MERCER, Department of Botany, University of Adelaide
(Communicated by J. G. Wood)

Summary

Pollen is an important source of hay-fever, and in recent years methods for estimating the pollen content of the air have been introduced and enabled records of atmospheric pollen throughout the year to be obtained. This, combined with the usual laboratory methods, enables the offending plants to be determined quickly.

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Department of Botany, University of Adelaide

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[Read 12 October 1939]

INTRODUCTION

Pollen is an important source of hay-fever, and in recent years methods for estimating the pollen content of the air have been introduced and enabled records of atmospheric pollen throughout the year to be obtained. This, combined with the usual laboratory methods, enables the offending plants to be determined quickly.

In 1938 a study of atmospheric pollen was commenced at Adelaide. This paper gives a preliminary account of the results obtained. The task has not been easy since the morphology and characteristics of the pollens of Australian families and certain introduced plants have not been described hitherto. Approximately 80 per cent. to 90 per cent. of the total pollen caught has been identified as belonging to definite families, and in many instances a more specific identification has been possible. A fraction containing about eleven different kinds of pollen and making up from 9 per cent. to 19 per cent. of the total number caught has not yet been identified. The pollen comprising this group occurs in very small quantities. This fraction is much higher (19 per cent.) in the region (Croydon) in proximity to wasteland and indicates that the probable source of these pollens is from weeds. Three kinds of grains, not yet identified, but occurring in small numbers over definite periods, have been separated from this group on account of their possible importance as sources of hay-fever.

A plant, to be an important cause of hay-fever, must fulfil several characteristics: (1) it must produce large quantities of pollen—a plant forming a small amount can only be a cause of local trouble; (2) the pollen must contain an excitant—Conifers are wind-pollinated and yield large amounts of pollen, but these plants are not important because their pollen is usually non-toxic; (3) the plant must be widespread—a species represented by a few individuals can be of little general importance.

These three features can best be seen in the wind-pollinated group of plants which disseminate large quantities of pollen in the air to secure pollination. Anemophily is found in many plants and appears to have originated independently in different families. Tremendous quantities of dry, spherical, buoyant pollen are shed, and are carried by air currents to the female flowers. The pollen is usually thin-walled, the exine devoid of elaborate sculpturings and the furrows reduced. The flowers are usually inconspicuous and unattractive to insects.

The majority of plant families are insect-pollinated. Bright, attractive flowers with well-developed nectaries are formed; this combination of characters

attracts insects which transfer pollen from one plant to another. The pollen grains are usually sticky, adhering together in lumps, and are sculptured or ornamented. These plants are frequently blamed for producing hay-fever; they may flower at the same time as an inconspicuous wind-pollinated plant, but because of their attractiveness, are thoughtlessly described as the cause of the trouble. The structure of the flower in these plants is often such that it is extremely unlikely that pollen is shed into the air in sufficient amounts to be of general importance.

METHOD

The technique adopted was similar to that described by Wodehouse (1935). A drop of melted methyl green glycerin jelly was placed in the centre of a microscope slide and spread out to about the area of a $\frac{3}{4}$ in. cover slip. These slides were exposed horizontally in specially constructed weather-vanes. Throughout the work the area counted was about four square centimetres. The counting was done with a mechanical stage using a 6X eyepiece and 8 mm. objective. Higher powers were used to identify the grains when necessary.

The sites were: (1) the Adelaide Town Hall at about seventy feet above street level, (2) the Botany Department at the University of Adelaide at twenty-five feet above ground level, and (3) at Croydon eighteen feet above the ground.

In the first two sites counts were made twice weekly on Tuesday and Thursday afternoons from 1 August 1938 to November 1938. Counting was then interrupted until March 1939, when it was recommenced. This was unfortunate, because November-December are the height of the late spring pollen season. At Croydon exposures were made daily from 1 August 1938 to 31 March 1939. From 1 April 1938 to 31 July 1939, tri-weekly counts were taken at all sites on Monday, Wednesday and Friday. This gave a more even distribution of the time of exposure, which until then was not identical for the three sites.

RESULTS

GENERAL DISCUSSION

The results obtained are shown graphically in figs. 1, 2, 3, and indicate a succession of pollen grains from different plants invading the atmosphere from time to time at Adelaide. Although separated by a half mile and two and-a-half-miles a very close correspondence is seen in the figures for the three sites. The period during which the pollen of any one species was caught was almost identical in each case. This was particularly evident with the spring flowering deciduous trees which had a well-defined pollination period.

The vegetation in the immediate neighbourhood of the sites varies somewhat—at Croydon large areas of land containing weeds are found; at the Botany Department numerous trees are growing in the University grounds and nearby gardens. These features, combined with the lower levels at which the readings were taken, result in an increase in the number of pollen grains caught from neighbouring plants (cf. high *Ash* count at the University).

Unfortunately, figures were not available for the Town Hall or University between November 1938-March 1939. However, since a fairly close correlation exists between amounts of pollen caught at all sites for the rest of the year, the Croydon figures may be taken as representative of the others.

An important feature shown is the absence of pollen from indigenous wind pollinated plants, for approximately 90 per cent of the pollen in the air is produced by introduced plants (cf. Table 1). The only native species represented are



Fig. 1
Record of atmospheric pollen in the City of Adelaide—Croydon chart.
Each division on the vertical axis equals five grains.

members of the Myrtaceae, *Acacia* spp., and possibly a few grasses and members of the Chenopodiaceae.

The total number of grains recorded were: 3,420 at Croydon (twelve months); 1,546 at the Town Hall (seven and a half months); and 6,060 at the Botany Department (seven and a half months). The numbers of grains belonging to different families or genera are given as percentages of the total number in Table I

		Grass %	Pine %	Cupressus %	Elm %	Plane %	Acacia
Croydon	-	34.5	4.5	5.0	1.0	4.5	1.0
Town Hall	-	16.8	22.9	13.5	7.0	7.0	0.4
University	-	6.0	60.0	2.0	4.6	2.4	0.1

		Unknown Species	Araucaria	No. 4 %	Myrtaceae	Chenopodiaceae %
Croydon	-	19.8	0.1	2.5	2.0	14.0
Town Hall	-	9.0	0.5	—	0.3	4.3
University	-	7.6	0.7	—	0.1	0.8

		Plantain %	Ash %	No. 2 %	Rosaceae %	No. 3	No. 5
Croydon	-	0.5	6.0	0.6	3.5	0.5	—
Town Hall	-	1.0	9.0	2.3	—	2.4	3.6
University	-	0.7	13.0	0.5	—	0.5	1.0

"x" Introduced Species

It will be noticed that 73 per cent. of the University count consists of pollen from only two species (*Ash* and *Pine*). This is due to the presence of these trees in the immediate locality. Such a high percentage over shadows the part played by other components. If we disregard this the readings for the other species are quadrupled, and this probably gives a more accurate measure of their general importance.

During July little pollen was found in the air; towards the end of the month, and in early August pollen from the early spring grasses was caught in small amounts. During August the total number commenced to increase; this continued throughout September and October, and reached a maximum of about thirty grains per day in the middle of the latter month. This was due to the spring grasses and trees (*Acacia*, *Pine*, *Elm*, *Palm*, *Cupressus*). The trees were by far the greatest producers of pollen at this time. A group of unknown pollens was also conspicuous. This was made up from numerous species. At the end of October a decrease in number occurred, due to the cessation of pollen-shedding by trees. In the middle of November another maximum was noted; this was the result of a large increase in the grass count. Throughout December the total decreased until about six grains per day was reached. This value was maintained except for minor fluctuations during January February and was produced by

grasses, plantain, Chenopodiaceae, Myrtaceae and unknown grains. A small increase occurred in January and early February due to the flowering of a species of *Tamarix* which grew in the vicinity, and was, therefore, likely to be more prominent at Croydon than elsewhere. In March an increase was noted which continued into April, and was due to the rapid rise in the Chenopodiaceae count. During the last week in March and the first week of April two unknown species were found, and they continued to be caught throughout April and May. Thereafter the total number of all species decreased, and only a few odd grains were caught in May, June and July. In June and July *Ash* pollen was caught in large quantities over a period of four weeks.

GRASS

INDIVIDUAL SPECIES

Grass pollen was one of the most important caught. Not only did it represent a large portion of the total but it was also present throughout most of the year. The pollen grains of the grasses are very similar and it was not possible to distinguish the various species by their morphological features, but by taking into account the flowering periods of the grasses commonly found around Adelaide it was possible to arrive at the probable sources of this pollen.

The first grains appeared during the latter part of July. At this time the only widespread species in flower were *Poa annua*, L. (annual meadow grass), and *Avena fatua* L. (wild oat). The count increased, reaching about five grains per day in the second week in August. This value was maintained except for minor fluctuations throughout September, October and the second week in November. During the second week in November a sudden rise occurred and a maximum of twelve grains per day was reached. At the end of the month a decrease to about four grains per day was noted. Throughout December the count steadily decreased until only one or two grains were caught per day. In the second week of January a very low count was recorded; this may have been due to the unusually hot weather experienced at this time—heat withered the mature flowers—and may not represent a normal reading. During March a small increase was noted; thereafter, in April and May only a few odd grains were caught, and the count finally fell to zero in June and July.

The flowering periods of grasses occurring commonly around Adelaide are: *Poa annua*, L. (annual meadow grass), July-December; *Avena fatua*, L. (wild oat) July-December; *Koeleria philcoides*, Pers., September-November; *Ehrharta longiflora*, Sm. (veldt grass), September-November; *Bromus mollis*, L. (soft brome), October-November; *B. maximus*, Desf. (great brome), October-November; *B. madritensis*, L. (Madrid brome), October-November; *Poa pratensis*, L. (Kentucky blue grass), October-December; *Hordeum murinum*, L. (barley grass), October-December; *Danthonia* spp., F. v. M. (Wallaby grass), spring-summer; *Lolium perenne*, L. (perennial rye grass), October-March; *L. subulatum*, Vis., (Wimmera rye grass), October-December; *Cynodon dactylon*, Rich. (couch grass), summer; *Chloris* spp. (windmill grass), summer; *Paspalum dilatatum*, Poir. (golden crown grass), February-April.

These grasses, with the exception of *Danthonia* spp., are all introduced species. They can be found in any vacant allotment, along roadsides and in many gardens. Their flowering periods overlap considerably, so that they can maintain a supply of pollen over long periods. This would account for the very steady value obtained for grass pollen during the greater part of the year. Maximum development (*i.e.*, when most species are in flower) is reached in November. This, as seen above, corresponds with the time when most grass pollen was in the air.

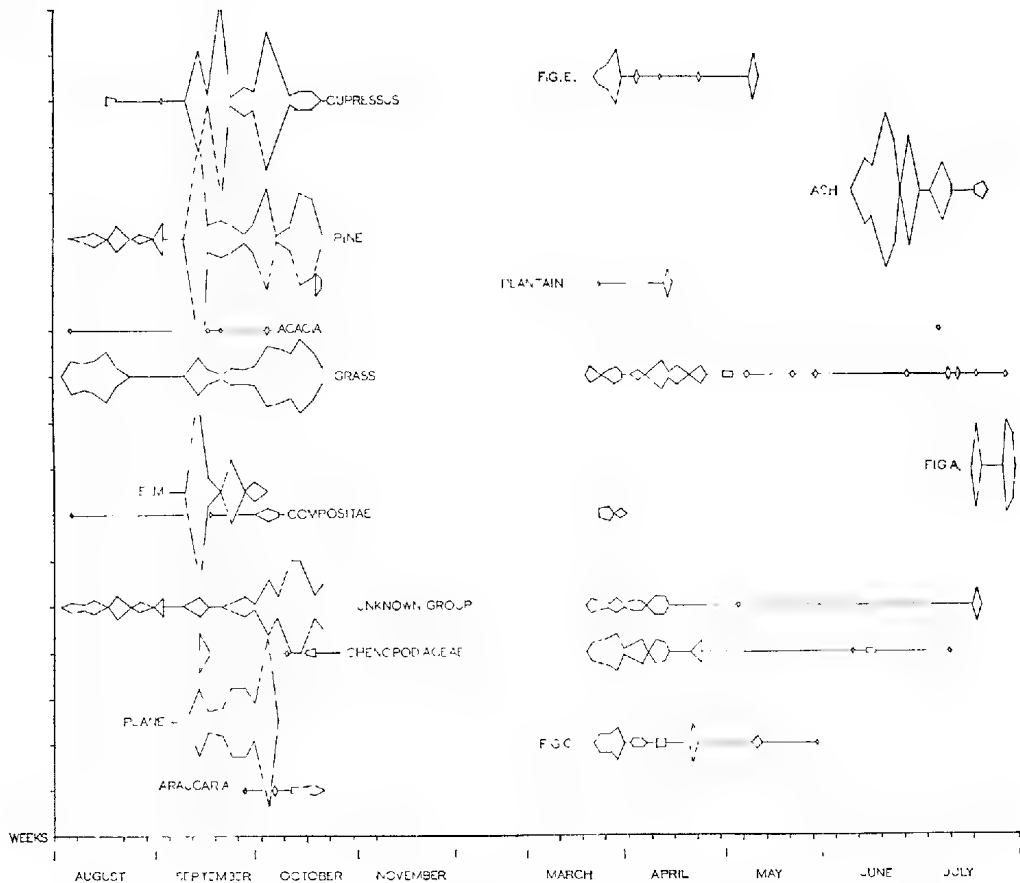


Fig. 2

Record of atmospheric pollen in the City of Adelaide—Town Hall chart.
Each division on the vertical axis equals ten grains.

PINE

The first pine pollen was caught during the second week of August and was present until the end of October. A maximum was reached on 6-8 September. The large quantities of this pollen in the air at the time can be gauged from the count (2,000 per 4 sq. cm.) recorded at the University. This was much higher than at the other two sites (Town Hall, 250; Croydon, 43). The most widely planted pines around Adelaide are *Pinus halepensis*, Bieb. (Aleppo pine), and

P. canariensis, C. Sm. (Canary Island pine). These species are probably responsible for 95 per cent. of the pine pollen found.

CUPRESSUS

Cupressus pollen was conspicuous during the spring months from the first week of August until the end of October. The maximum occurred between the middle of September and the first week of October, but was not well defined. At the Town Hall a reading of 1,500 grains per unit area was recorded on 20th September. Various species of *Cupressus*, chiefly *C. torulosa*, Don., *C. macrocarpa*, Hart (Monterey cypress), *C. Lawsoniana*, Murr., and varieties are grown in gardens, and these are doubtless the source of this pollen.

ELM

Pollen shedding commenced at the end of August, was well defined, and continued for five weeks. The English Elm, *Ulmus campestris*, L., is planted extensively in the city. The trees grow to a large size and a single specimen is capable of shedding much pollen, as is evident from the large counts at the Town Hall and University.

ASH

The English Ash, *Fraxinus excelsior*, L., is probably the commonest tree in the city and suburban streets and gardens. This explains the high Ash count recorded for each site. Pollen shedding occurred from 7 June to 14 July, much light pollen was shed and a count of 141 grains was recorded at the University from 19 to 21 June. Ash was the only pollen noted in any quantity during the winter months.

ACACIA

Acacia pollen was found occasionally (an odd grain or two at a time) from July-November. A small increase occurred in October at Croydon, caused by a tree flowering in the neighbourhood. Several species of *Acacia*, especially *A. dealbata*, Link., and *A. decurrens*, Willd., are fairly common in suburban areas and probably most of the *Acacia* pollen was derived from these species.

PLANE

The Plane, *Platanus orientalis*, L., is extensively planted in streets and gardens. It flowered from the first week in September to first week in October and much light pollen was shed.

Stellate hairs from the under surfaces of the leaves were found frequently on the slides, especially in the spring months. A second type of hair produced from the fruits which commenced to disintegrate in late autumn was noted throughout the winter and early spring. Several large Plane trees growing in the University grounds account for the high Plane figures at this site. A great deal of local controversy is centred around the Plane. Our results indicate that botanically it can be regarded as a potential source of hay-fever. It is widespread and produces large quantities of pollen and hairs, and thus fulfils several of the characteristics of an important hay-fever offender.

ARAUCARIA

Araucaria pollen was caught on the slides for about four weeks from 20 September to 13 October. The close proximity of the Botanic Gardens explains the high University count. The grains represented were probably *Araucaria Bidwillii*, Hook. (bunya-bunya pine).

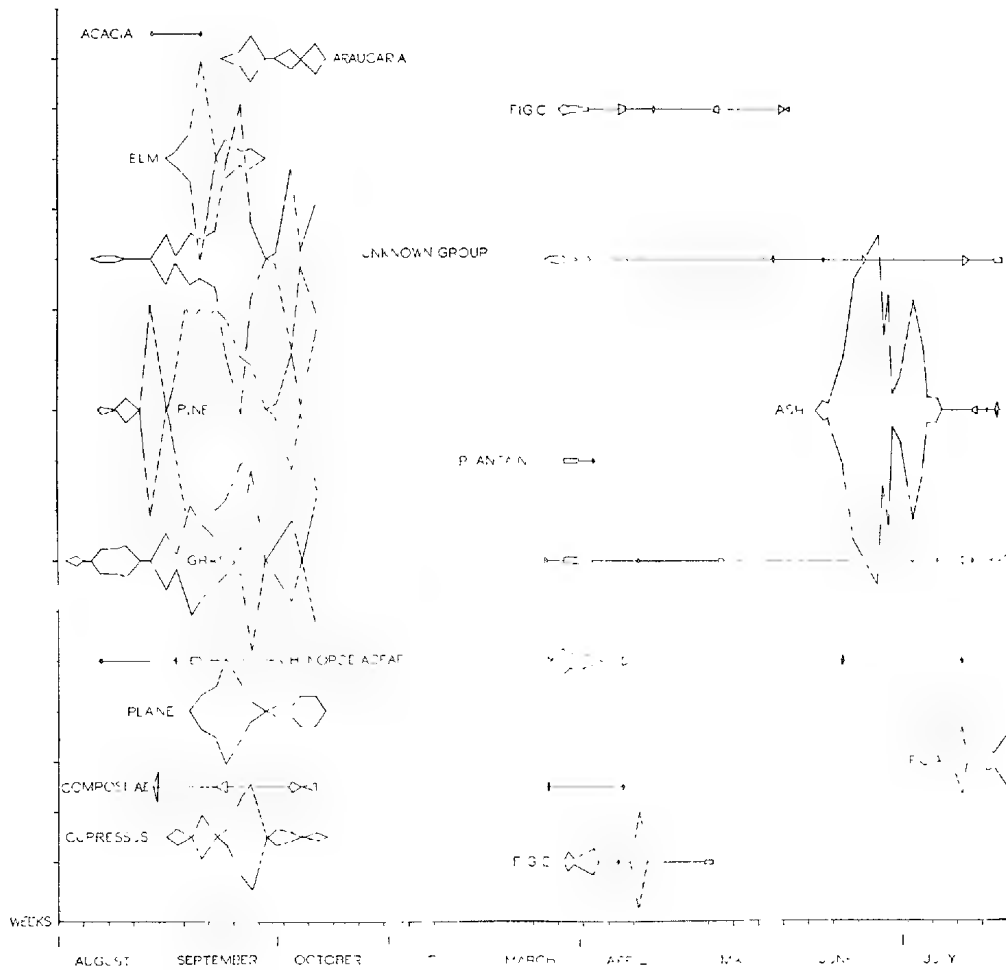


Fig. 3

Record of atmospheric pollen in the City of Adelaide—University chart.
Each division on the vertical axis equals twenty grains.

COMPOSITAE

Compositae pollen occurred sporadically from November to March. The large number of Compositae and the similarity of their pollen render it difficult to determine the origin of these grains. During the autumn *Erigeron crispus*, Pourret., was fairly common in waste places. The pollen of this plant conformed with the type of grain caught on the atmospheric slides at this time.

TAMARIX

This pollen was noted at Croydon for about three weeks in January. It is over-conspicuous at this site because of the influence of near-by trees. These results can, therefore, apply only to isolated areas in which the species is found.

PLANTAIN

The English plantain (*Plantago lanceolata*, L.) is a common weed and sheds large amounts of pollen over a long period, from November-March. From 5 to 12 December a series of slides were exposed at North Adelaide in an area infested with plantain. During this period 258 grains, an average of 37 grains per day, were noted; but generally plantain pollen never reaches a high concentration.

CHENOPODIACEAE

The pollen grains of the Chenopodiaceae and Amarantaceae are not distinguishable, and it is very probable that both families are represented in the group. This pollen was noted in small quantities (2-7 grains per week) from August 1938 to May 1939. A maximum occurred from the first week of March until the middle of April. This was particularly prominent at Croydon. During these weeks that of the Chenopodiaceae was the most prevalent pollen and represented approximately 50 per cent. of the total pollen caught. Because of the similarity of the grains it is only possible to indicate their probable origin. The following species are found in many areas: *Chenopodium murale*, L. (nettle-leaved goosefoot), August-April; *C. album*, L. (white goosefoot), November-August; *Amarantus viridis*, L., January-March. These species attained their greatest development during the autumn which corresponds with the Chenopodiaceae-Amarantaceae maximum pollen count. The ubiquitous *C. murale* was the most important species.

The possibility exists that native Chenopods were also contributory factors. These plants are fairly common near the sea coast, and their pollen may blow in to the city.

ROSACEAE

Pollen of the family Rosaceae was common at Croydon during August and early September. Numerous almond trees grow in the vicinity, and the pollen of this species corresponds with that found on the slides. The absence of this pollen from the other sites indicates that it does not travel far from the point of production; but in the neighbourhood of almond groves the concentration of rosaceous pollen would be rather high.

POLLEN No. 1 (figs. D, D₁)

Triangular in polar view, the edges of the triangle 19μ to 25μ long. Tricolpate, furrows narrow, slit-like, and appear to meet at the poles. The lunes must be somewhat triangular in outline to conform with the rigid triangular equator. The grain appears as if composed of a number of triangles—a triangular

hexahedron; if this is the case the furrows will traverse the outer edges of the hexahedron. The lunes sometimes lose their individual shape and fuse; this imparts an irregular appearance to the grain. Germ pores smooth spherical and may or may not protrude. Exine smooth and rigid.

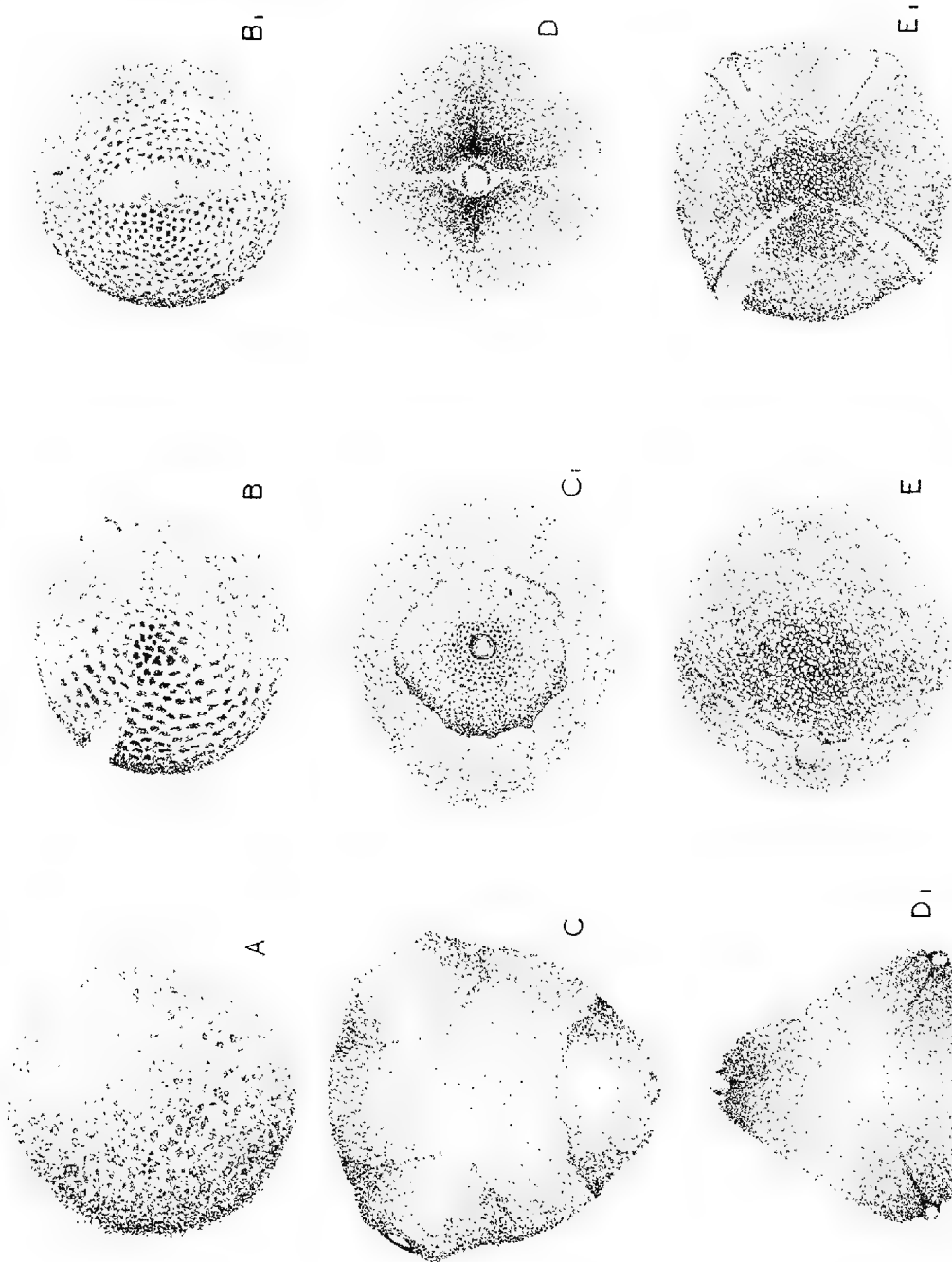


Fig. 4

A Pollen No. 3 Polar view
 B Pollen No. 4 Polar view
 C Pollen No. 1 Polar view
 D Pollen No. 1 Polar view
 D1 Pollen No. 1 Side view
 E Pollen No. 2 Polar view
 E1 Pollen No. 2 Side view
 B1 Pollen No. 4 Side view

All drawings freehand of fully expanded grains to a magnification of 500 diameters.

A grain or two at a time of pollen corresponding to this description was found from November-March. This type of grain is characteristic of the family Myrtaceae. The absence of data dealing with pollen morphology does not exclude the possibility that it is also characteristic of other families; this group, therefore, may not be an entity. The long period during which these grains were caught corresponds to the combined flowering periods of myrtaceous plants around Adelaide. Several species of *Eucalyptus*: *E. leucoxylon*, F. v. M. (blue gum), *E. rostrata*, Schlecht. (red gum), *E. ficifolia*, F. v. M. (scarlet flowering gum), *E. calophylla*, R. Br., *E. globulus*, Labill. (Tasmanian blue gum), are common in the city environs, and the pollen from these species probably represents at least a portion of the group.

UNKNOWN GROUP

As already indicated this group consists of a number of different pollens. The following grains were separated from this fraction:

POLLEN No. 2 (figs. E, E₁)

Grains mostly spherical, a few slightly irregular $25\mu \pm 3\mu$. Furrows four, long, tapering almost from pole to pole, each enclosing a single slightly elliptical germ pore. Pores equatorially arranged, with long axis at right angles to the furrow. Exine finely pitted, furrow membrane smooth.

POLLEN No. 3 (figs. C, C₁)

Spherical angular, 2μ to 38μ , pores three, usually prominent, conical irregular at base, protruding and imparting to the grain a trilobed appearance; the actual germ pore is spherical, approximately 3μ in diameter; exine very faintly pitted.

Both grains, Nos. 2 and 3, occurred from the end of March until the last week of April; although never reaching a high concentration they were important, being present at a time when little other pollen was about.

The pollen of the family *Casuarinaceae* corresponds with the latter description. Several native members, *Casuarina strictis* and *C. Muelleriana* are fairly common in the nearby hills and pollen from these species is almost certainly represented in this group.

POLLEN No. 4 (figs. B, B₁)

Spherical, slightly irregular, tricolpate, furrows not conspicuous, about 6μ - 8μ wide at equator, germ pore approximately 5μ , exine finely reticulate. This was fairly conspicuous at Croydon from the end of October to the last week of November.

POLLEN No. 5 (fig. A)

Spherical 22μ to 28μ . Exine thin and easily ruptures, covered with numerous granules; intine thick and the inner edge somewhat irregular. This grain resembles those seen in some of the Coniferae. It occurred chiefly at the Town Hall and University sites from the middle of July until late August.

It will not be an easy task to determine the sources of the individual pollen species of this fraction; some are possibly derived from native families, but the greater percentage are probably from introduced species.

LAGUNARIA HAIRS

Hairs from the seed pods of *Lagunaria Patersonii*, G. Don, were occasionally found on the slides during the spring.

FACTORS INFLUENCING POLLEN CONTENT OF AIR

Because of the variation and length of exposures it was possible only to note in a general way the effect of meteorological factors. Generally speaking rain had a clearing effect and low counts were obtained in wet weather. The opposite result was observed during sunny conditions, providing that plants were in flower at the time.

The most important factor influencing pollen distribution is the nature of the vegetation in the city. The influence of introduced and garden plants is clearly seen. Much of the vacant land in the vicinity of the city has been colonised by alien plants, and these areas form the main regions for production of atmospheric pollen.

SUMMARY

(1) The succession and percentages of different pollen grains in the air from month to month at Adelaide are described.

(2) The most important factor determining the cycle is the nature of the vegetation in the city and environs.

ACKNOWLEDGMENTS

The author's thanks are due particularly to Professor J. G. Wood who suggested this research, for his helpful suggestions and interest; to Dr. F. Ray Hone for his assistance; and the Adelaide City Council who provided facilities for carrying out the work.

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THE NAUTILOID BATHMOCERAS BARRANDE

By CURT TEICHERT, Crawley Western Australia

Summary

The genus *Bathmoceras* Barrande is one of the most remarkable genera of the nautiloid cephalopods. It is known by one species from the neighbourhood of Lake Huron, North America, by one other species from Sweden and by two species from Bohemia. In all these places it occurs in the Ordovician, and each species is only known by one or a very few specimens. To these a species from the Ordovician of Central Australia, so far represented by one specimen only, is here added.

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[Read 12 October 1939]

PLATE XIX

The genus *Bathmoceras* Barrande is one of the most remarkable genera of the nautiloid cephalopods. It is known by one species from the neighbourhood of Lake Huron, North America, by one other species from Sweden and by two species from Bohemia. In all these places it occurs in the Ordovician, and each species is only known by one or a very few specimens. To these a species from the Ordovician of Central Australia, so far represented by one specimen only, is here added.

In 1856 Barrande described a specimen from Bohemia as *Orthoceras complexum*, and in 1865 he attached the generic name *Bathmoceras* to this species. A brief description of this genus was published by the same author in 1867 (p. 73), and a second species, *Bathmoceras praeposterum*, was added. He described the siphuncle as composed of "une série de petits cornets; en forme d'éteignoirs, superposés l'un de l'autre, en dirigeant leur pointe vers l'ouverture." More elaborate descriptions and discussions of the affinity of the genus followed in 1874 (pp. 792-797) and Barrande reviewed the genus a third time in 1877 (pp. 92-93). He then announced its discovery by Swedish geologists in the Ordovician rocks of Sweden.

A description of the Swedish form followed in 1880 by Angelin and Lindström under the name of *Bathmoceras linmarssoni*, and this species was made the subject of an admirable morphological study by Holm in 1899.

Barrande, in 1874, suspected the identity of his *Bathmoceras* with the genus *Conoceras*, established by Bronn in 1837 (p. 98) on a specimen from the Lake Huron Region figured by Bigsby in 1824 (pl. 26, fig. 6). In consequence, Hyatt and others gave preference to the name *Conoceras*, but since then, Ulrich and Foerste, in 1934, observed that *Conoceras* is an endoceroid, and not identical with *Bathmoceras*.

Up to the time of Holm's investigations the affinities of *Bathmoceras* had been very doubtful and the genus was thought to represent, together with *Nothoceras* Barrande, a special group of nautiloids which was called "Prochoanites" by Hyatt (1884) and "Prosifonata" by Fischer (1887), and in which the septal funnels were supposed to be directed forward instead of backward as in other nautiloids.

Holm's investigations went to show that *Bathmoceras* has an ellipchoanoidal siphuncle and possesses very peculiarly shaped deposits within the siphuncle which were explained in elaborate descriptions and figures of serial sections and reconstructions.

In 1900, Hyatt, presumably without knowledge of Holm's paper, established the sub-order Schistochoanites for *Conoceras* (= *Bathmoceras*) and *Nothoceras*

which in the revised definition were supposed to be characterised by "more or less incomplete funnels." It may be mentioned that Saemann in 1852 (p. 152) and Foord in 1888 (p. 322) erroneously regarded *Conoceras* as a synonym of *Gonioceras* Hall, an altogether different genus. Furthermore, Blake, in 1882, though under the assumption that *Bathmoceras* was a synonym of *Conoceras* (p. 53), described as *Conoceras eoum* a specimen from the English Arenig (p. 165) which apparently has no similarity with either of these genera.

No investigations similar to Holm's morphological studies of *Bathmoceras linnarssoni* have been made on representatives of any of the other species mentioned above, but there is very little doubt that the conspicuous acute ventral saddle of the sutures is such an extraordinary feature that all these species must be regarded as congeneric and very probably will turn out eventually to possess siphuncular structures more or less similar to those of *Bathmoceras linnarssoni* from Sweden.

In this paper I merely want to call attention to its unexpected occurrence in the Ordovician of Central Australia, where it was first recognised by Miss M. E. Turner as recorded by Madigan in 1932 (b, p. 112).

SIGNIFICANCE OF BATHMOCERAS FOR THE CORRELATION OF THE LARAPINTINE SERIES

The only Ordovician fossils of Central Australia have been found in the Larapintine series of the Macdonnell Ranges, the stratigraphy of which has been described in detail in two publications by Madigan (1932, a and b). The series is approximately 6,000 feet thick, but fossils are almost entirely confined to a calcareous shale, 74 feet thick, about 2,200 feet below the top of the series (see Madigan, 1932, a, pp. 693-694). This fossiliferous shale has furnished a fauna of brachiopods, lamellibranchs, nautiloids, and trilobites described in various early publications by R. Etheridge, jun., and by Tate. Strikingly Baltic affinities were recognised by both authors, particularly by Etheridge.⁽¹⁾ The specimen of *Conoceras*, described below, was given to Dr. Madigan at the Hermannsburg Mission Station and comes, presumably, from these same strata, in the western part of the Macdonnell Ranges. Any conclusions with regard to the exact age of this Ordovician fauna apply, therefore, exclusively to the age of the deposition of this fossiliferous band and not to the entire Larapintine series. Fortunately, the occurrence of *Bathmoceras* in this band permits us to determine the age of this band within narrow limits.

In Sweden *Bathmoceras linnarssoni* was found in the "Grey Vaginatum limestone" of Kinnegulle⁽²⁾ in the province of Västergötland and in the "Grey

⁽¹⁾ A revision of the cephalopods with references to these papers, now difficult to obtain, will be published later.

⁽²⁾ Raymond (1916, p. 215) doubted this. He wrote: "The numerous cephalopods assigned to this zone [Asaphus limestone] in lists seemed to be derived from the lower part of the 'Upper Red' and possibly to indicate Gigas rather than Asaphus kalk. Among these are *Vaginoceras wahlenbergi* (Foord), *Bathmoceras linnarssoni* (Ang.) and *Estonioceras pretus*." This suggestion is very vague, and no further evidence seems to have been forthcoming to support it.

his horizon d_1 . Barrande's original subdivisions of the Palaeozoic strata of Bohemia have been subject to amendments and alterations by later workers and Barrande's " d_1 " now comprises a series of horizons ranging in age from early Tremadoc to Llandeila. However, Barrande mentions that *Bathmoceras* occurs together with *Phacops* (now *Placoparia*) *zippei*, a species characteristic of zone d_7 in Kettner and Kodym's arrangement which is now in use. Zone d_7 , also known as Sárka beds, is regarded as an equivalent of the Llanvirn. It contains *Didymograptus geminus*, which in Sweden makes its first appearance in the Lower *Didymograptus* shale (zone with *Phyllograptus* cfr. *typus* = zone with *Didymograptus bifidus* in Great Britain). The Sárka beds of Rokycany are, therefore, of Llanvirn age, perhaps corresponding more closely to the Lower Llanvirn (see also Kettner and Bouček, 1936, pl. i and iv). Moreover, Dr. B. Bouček, in a letter dated 8 May 1939, tells me that *Bathmoceras* is restricted to d_7 (Sárka beds), where, though never abundant, it is characteristic of the lower part of this series. Thus, in Bohemia, *Bathmoceras* makes its first appearance very slightly later than in Sweden. The genus apparently left Sweden and migrated into Bohemia at the beginning of *Didymograptus bifidus* time.

It is very unlikely that a highly specialized type like *Bathmoceras* developed several times in different parts of the world and approximate contemporaneity, or at least close continuity, must be assumed for its occurrence in Europe and Australia. The age of the fossiliferous strata of the Larapintine series in which *Bathmoceras* is found can, therefore, not differ appreciably from that of the *Asaphus* limestone of Sweden of the Sárka beds (Zone d_7) of Bohemia and must closely correspond to that of the very late Skiddavian and early Llanvirn of Great Britain.

In Victoria, according to the latest correlation by Harris and Thomas (1938), the British zones of *Didymograptus hirundo* and *Didymograptus bifidus*—those to whose equivalents the occurrence of *Bathmoceras* in Europe is restricted—correspond to the zones with *Didymograptus austrodentatus* and *Didymograptus interstitus*, viz., the lowest part of the Darriwilian. Even if some allowance is made for the time required for the migration of *Bathmoceras* from European to Australian waters, it can be concluded with some degree of certainty that the fossiliferous strata of the Larapintine are to be correlated with the lower part of the Darriwilian of Victoria.

As has been emphasised, this correlation applies only to the fossiliferous strata 2,200 feet below the top of the Larapintine. It must, however, be borne in mind that a long period of time was required for the formation of a graptolite zone. Poulsen has recently shown (1934, pp. 45-46) that a Silurian limestone series in North Greenland (Offley Island formation) which is between 500 and 800 meters (1,600 to 2,600 feet) thick corresponds but to one single graptolite zone of the British graptolite facies. It is, therefore, quite possible that the entire Larapintine series of Central Australia does not correspond to more than a few of the Victorian graptolite zones and may not represent more time than, say, the Yapeenian and Darriwilian of Victoria.

PALAEONTOLOGICAL DESCRIPTION

Family BATHMOCERATIDAE Holm

Holm, in 1899, recognised the unique characters of *Bathmoceras* and established the family Bathmoceratidae for this genus. According to Ulrich and Foerste (1934) the family should also include the genus *Conocerina* Ulrich and Foerste. It is most likely that the members of this family are an early off-shoot of the actinosiphonate cephalopods (Cyrtoceroidea).

Genus BATHMOCERAS Barrande, 1865

The genus can be characterised as follows (mainly after Holm 1899, p. 287): Orthocones with wide marginal siphuncle, ellipchoanoidal funnels. In the siphuncle there are peculiar wall-like, adorally directed structures, originating by corresponding deep incisions in the fleshy siphon. Sutures with strong, arrow-like, acute lobes on the ventral side.

Genotype—*Bathmoceras complexum* Barrande.

***Bathmoceras australe* n. sp.**

Diagnosis Characterised by strongly depressed cross-section, short camerae and slow rate of expansion of the conch.

Description—The holotype and only specimen of this species is an internal mould of a portion of a phragmocone with attached adapical part of the living chamber. The entire specimen is 71 mm. long. Of this length 48 mm. are occupied by the phragmocone, of which 25 camerae are preserved. The average length of the camerae is thus about 2 mm. However, in the adapical part the camerae are somewhat shorter, whereas they are longer in the adoral part, an exception being the last camera which is only 1.4 mm. long. The lateral diameter of the conch increases from 23.4 mm. at the adapical end to 31.7 mm. at the adoral end. The corresponding figures for the dorso-ventral diameter are 17.5 mm. and 22.3 mm. This increase in diameter is almost entirely attained in the adapical part of the portion of the phragmocone preserved. At a distance of 33 mm. from the adapical end the lateral diameter is 30.5 mm. and the dorso-ventral 17.5 mm. and 22.3 mm. This increase in diameter is almost entirely attained in the adapical part of the portion of the phragmocone preserved. At a distance of 33 mm. from adapical end the lateral diameter is 30.5 mm. and the dorso-ventral diameter 22.3 mm. The rest of the phragmocone and the living chamber are almost cylindrical. The living chamber seems to be slightly constricted in its lower part between the bottom and an area approximately 13 mm. from the bottom, but it is possible, though not likely, that this constriction is due to weathering of the specimen. Also, the ventral side of the conch seems to be very slightly convex, whereas no corresponding concavity of the dorsal side is noticeable. Until additional specimens have been found, it seems impossible to state definitely whether the convexity of the ventral side is a natural feature of the conch or due to distortion after embedding.

The sutures form low lateral saddles and a broad and shallow dorsal lobe. Ventrally, the sutures form a broad, though slightly deeper lobe which, however, near the siphuncle in the middle part of the ventral side is interrupted by the formation of an acute saddle, 5 to 6 mm. wide at its base and approximately equivalent to two camerae in height. This saddle is also developed in the last suture, indicating the shape of the septum which forms the base of the living chamber.

The siphuncle is in contact with the ventral wall of the conch. Its cross-section is approximately circular and its diameter 6.3 mm., measured at the apical end of the specimen. Owing to the uniqueness of the specimen no attempt has been made to section the siphuncle, but from a study of weathered parts of its surfaces it appears that probably its structure is rather similar to that of the siphuncle of *Bathmoceras linnarssoni* as described by Holm.

Horizon and Locality—Larapintine series, undoubtedly from the fossiliferous strata 2,200 feet below the top of the series; Horn Valley, Glen Helen, Western Macdonnell Ranges, Central Australia. The holotype in the Department of Geology, University of Adelaide.

Remarks—The Australian species is easily distinguished from the Swedish *Bathmoceras linnarssoni* by its smaller size and from the American *B. angulosum* by the smaller rate of enlargement of the conch. The Bohemian *B. praeposterum* differs in the more circular cross-section of the conch. *B. complexum* from Bohemia is evidently more closely similar to *B. australe* than any other species. Both have a depressed cross-section and in both the living chamber is slightly constricted in the adapical part at some distance from the last septum. The only perceptible difference is in the shape of the ventral saddle of the sutures which is wider in *B. complexum* than *B. australe*. This feature seems of sufficient importance to require specific separation of two otherwise very closely allied species.

ACKNOWLEDGMENTS

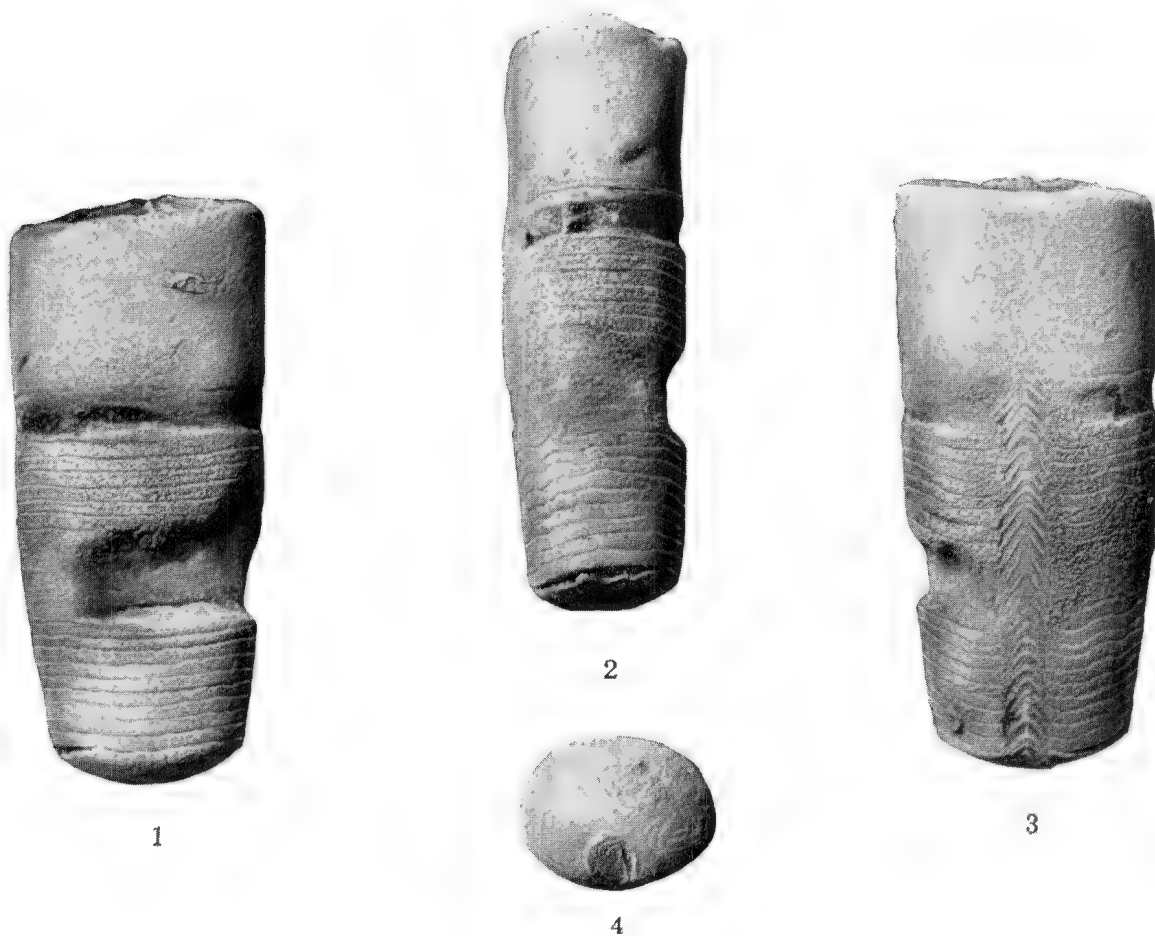
The writer is indebted to Professor Sir Douglas Mawson and to Dr. C. T. Madigan for the loan of this interesting specimen. Dr. Madigan kindly furnished information regarding the circumstances of the find. The writer also wishes to thank Dr. B. Boucek of the Narodní Museum, Prague, for information regarding the distribution of *Bathmoceras* in Bohemia.

SUMMARY

A representative of the rare nautiloid genus *Bathmoceras* is described from the Ordovician Larapintine series of Central Australia. The distribution of this genus in Europe and North America is discussed and it is concluded that the fossiliferous beds of the Larapintine series can be correlated with the late Skiddavian and early Llanvirn of Great Britain, with the *Asaphus* limestone of Sweden, with the Sárka beds (zone *dy*) of Bohemia, and with the Lower Darriwilian of Victoria.

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Figs. 1-4 *Bathmoceras australe* n.sp. Holotype
(1) dorsal, (2) lateral, (3) ventral, (4) apical views . Nat. size

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OBITUARY NOTICES

THE HON. SIR LANGDON BONYTHON, K.C.M.G

It is with deepest regret that the Society has to record its loss by death of the Hon. Sir Langdon Bonython. Although he had been a Fellow of our Society for only a few years, and would have made no claim to be a scientific worker, yet he did such yeoman service to this State over a period of sixty years in the cause of education, that both the Society, one of whose objects has always been the encouragement of education, and the general community will long have reason to remember his work with gratitude and appreciation.

OBITUARY NOTICES

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He was Chairman of the Adelaide School Board as far back as 1883, in the days before education was made free for all. The influence of Mr. Bonython, as he was then, was exerted through his newspaper on the side of free education for all, which was ultimately brought about by the Act of 1891.

Largely instigated by him and supported by the powerful influence of "The Advertiser," the School of Mines and Industries Act was passed in 1888 at a time when there was no provision whatever for technical education in the State. The school was started in the basement of the Exhibition Building in 1889 under the Presidency of Sir John Cockburn, who resigned a few months later on becoming Premier. He was succeeded as President by Mr. Bonython, who held office continually for fifty years and was knighted nine years after his election as President.

During his long term of office he made the remarkable record of never missing a single meeting of the Council, except on the few rare occasions when he was out of the State. He saw the school grow from about two hundred students at the outset to over five thousand individuals.

In 1916 he was elected to the University Council and remained an active member until his death.

He was a generous benefactor to both the University and the School of Mines, the Bonython Hall, Bonython Laboratories for Mining and Metallurgy, and the Bonython Chair of Law representing munificent gifts that will not only perpetuate his name, but be of everlasting advantage to the community.

He was a member of the first and second Commonwealth Parliaments, from 1901 to 1906, and he exerted considerable influence on the guidance of the State through the medium of his newspaper, but his active and potent interest in education was undertaken to serve a cause which he regarded as fundamental to the growth and progress of the State.

His was a remarkable life, not only because of his personal achievements, but because it deservedly was the best tribute that can be paid to any man, that he leaves his country the better and the richer for the way in which he lived.

ROBERT CHAPMAN

ALFRED ALLEN SIMPSON

Alfred Allen Simpson, C.M.G., C.B.E., F.R.G.S., whose death occurred after a long illness on 27 November 1939, had been a Fellow of the Society since 1920. Born at Kent Town in April 1875, he was the eldest son of the late Mr. Alfred Muller Simpson who arrived in Australia in 1849. Alfred Allen, like his father, became Chairman of Directors of the firm of A. Simpson & Son Ltd., which was established by his grandfather, Alfred Simpson, in Gawler Place in 1855. Besides his business activities, he held a number of important positions in the public life of the community, amongst which was that of Mayor of Adelaide. The honours conferred upon him are an appreciation of his public-spirited services.

His reading was extensive, his memory excellent and his interests wide. Many overseas visiting scientists and others have been hospitably entertained at his home at Burnside. On the occasion of the visit, in 1925, of Dr. Clark Wissler and Mr. E. R. Embree, representing the Rockefeller Foundation, in connection with the proposals for Anthropological Research in Australia, this Society held a reception for the visitors and Mr. Embree stayed with Allen Simpson as his guest. The financial assistance rendered later by the Rockefeller Foundation was responsible for much of the recent important work in Anthropology in South Australia. The firm of A. Simpson & Sons Ltd were generous contributors to the Australasian Antarctic Expedition under Sir Douglas Mawson in 1911-1914, and the brothers, Allen and Fred., in similar fashion supported the B.A.N.Z.A.R. Expeditions of 1929-1931. Sir Douglas, in the course of the latter, named Cape Simpson on the coast of MacRobertson Land after Allen Simpson.

Allen Simpson was for many years associated with the South Australian Branch of the Royal Geographical Society and was its President from 1925 to 1930. Under its auspices and with the co-operation of the Defence Department, Dr. C. T. Madigan in 1929 made an aerial investigation of an area of unknown desert north of Lake Eyre of approximately 56,000 square miles in extent. On his return he named this desert after the President, Allen Simpson. In the winter of the present year, Dr. Madigan with a land party, including Mr. Robert Simpson, second son of Allen, successfully crossed the Simpson Desert from west to east on camels. Allen Simpson's generosity made this expedition possible, and in spite of the severe disabilities of his illness he followed every detail of its progress with intense interest. South Australia is notable for the public spirit of its citizens, and Alfred Allen Simpson occupies an honourable position amongst those who have served their country.

J. B. CLELAND

ROYAL SOCIETY OF SOUTH AUSTRALIA (INCORPORATED).

Receipts and Payments for the Year ended September 30, 1939.

ROYAL SOCIETY OF SOUTH AUSTRALIA (INCORPORATED).

Receipts and Payments for the Year ended 30 September 1939

RECEIPTS.			PAYMENTS.		
	£	s. d.		£	s. d.
To Balance, 1 October 1938	194	4 1	By Transactions (Vol. 62., Pt. 2, and Vol. 63, Pt. 1)—		
" Subscriptions	134	18 6	Printing	348	17 4
" Government Grant for Printing Vol. 62 and part Vol. 63			Illustrating	95	14 10
" Use of Room by other Societies	6	13 0	Publishing	15	10 0
" Sale of Publications	11	13 2			
" Sundry Receipts	0	11 2	Librarian	460	2 2
" Interest—			" Sundries—	38	10 0
Transferred from Endowment Fund	207	11 3	Conversazione	9	1 0
			Cleaning and Lighting	11	1 1
			Printing, Postages and Stationery	18	5 3
			Petties	7	18 1
			Typing	2	5 0
			Insurances	6	18 4
			Bank Fee and Cheque Books	1	2 6
				56	11 3
				10	0 0
			Research Fund		
			" Balance, 30 September 1939—		
			Savings Bank of S.A.	167	14 4
			Bank of Australasia	171	3 0
			Less Outstanding Cheques	10	2 0
				161	1 0
				328	15 4
				£893	18 9

Audited and found correct. We have certified the respective Bank Balances.

O. GLASTONBURY, F.A.I.S., A.F.I.A. } Hon.
F. M. ANGEL } Auditors

H. WOMERSLEY, Acting Hon. Treasurer

Adelaide, 9 October 1939

ROYAL SOCIETY OF SOUTH AUSTRALIA (INCORPORATED).

(a) ENDOWMENT FUND as at 30 September 1939
(Capital—Stocks at Cost Price £5,782 11s. 1d)

	£	s.	d.	£	s.	d.	£	s.	d.
1938—1 October									
To Balance—									
Australian Consolidated Stock	5,762	0	0				207	11	3
Savings Bank of S.A.	20	11	1						
				5,782	11	1			
Interest—									
Inscribed Stocks	198	19	0						
Savings Bank of S.A.	8	12	3						
				207	11	3			
				£5,990	2	4			
							£5,990	2	4

(b) RESEARCH FUND as at 30 September 1939

	1938—1 October			1939—30 September			
	£	s.	d.	£	s.	d.	
To Balance	16	0	0	By Grant—C. P. Mountford	10	0	0
„ General Fund	10	0	0	„ Balance—Savings Bank of S.A.	16	0	0

Audited and found correct. We have verified the Government Stocks at the Registries of Inscribed Stocks, Adelaide, and the Bank Balances at the Savings Bank of South Australia.

O. GLASTONBURY, F.A.I.S., A.F.I.A. } Hon.
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Adelaide, 9 October 1939

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The last award of the Medal was made by the Society at the Annual Meeting in October, 1938, to Prof. J. A. Prescott in recognition of his researches on soil problems, which work was carried out mainly at the Waite Institute, Glen Osmond, and the results largely published in the Transaction of the Society.

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1931 PROF. SIR DOUGLAS MAWSON, O.B.E., D.Sc., B.E., F.R.S.
1933 PROF. J. BURTON CLELAND, M.D.
1935 PROF. T. HARVEY JOHNSTON, M.A., D.Sc.
1938 PROF. JAMES A. PRESCOTT, D.Sc., A.I.C.

LIST OF FELLOWS, MEMBERS, ETC.

AS ON 30 SEPTEMBER 1939

Those marked with an asterisk (*) have contributed papers published in the Society's
Transactions. Those marked with a dagger (†) are Life Members.

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Date of
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1918. *JENNISON, REV. J. C., 7 Frew Street, Fullarton, Adelaide.
1910. *JOHNSON, E. A., M.D., M.R.C.S., "Tarni Warra," Port Noarlunga, S.A.
1934. JOHNSTON, J., A.S.A.S.M., A.A.I.C., A.A.C.I., Sewage Treatment Works, Glenelg, S.A.
1921. *JOHNSTON, PROFESSOR T. HARVEY, M.A., D.Sc., University, Adelaide—**Sir Joseph Verco Medal**, 1935; **Rep.-Governor**, 1927-29; **Council**, 1926-28; **Vice-President**, 1928-31; **President**, 1931-32; **Secretary**, 1938-; **Rep. Fauna and Flora Board**, 1932-39.
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1933. *KLEEMAN, A. W., M.Sc., 46 Byron Road, Black Forest, S.A.
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1931. *LUDBROOK (MRS. W. V.), N. H., M.A., Elimatta Street, Reid, F.C.T.
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1922. *MADIGAN, C. T., M.A., B.E., D.Sc., F.G.S., University of Adelaide—**Council**, 1930-33; **Vice-President**, 1933-35, 1936-37; **President**, 1935-36.
1923. MARSHALL, J. C., Mageppa Station, Comaum, S.A.
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1933. MAGAREY, MISS K. de B., B.A., B.Sc., 301 Unley Road, Adelaide.
1932. MANN, F. A., C/o Bank of Adelaide, Adelaide.
1929. MARTIN, F. C., M.A., Technical High School, Thebarton, S.A.
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1938. *MAWSON, MISS P. M., M.Sc., University, Adelaide.
1920. MAYO, HERBERT, LL.B., K.C., 16 Pirie Street, Adelaide.
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1925. †MITCHELL, PROFESSOR SIR W., K.C.M.G., M.A., D.Sc., Fitzroy Terrace, Prospect, Adelaide.
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1938. MOORHOUSE, F. W., M.Sc., Chief Inspector of Fisheries, Flinders Street, Adelaide.
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1925. †MURRAY, HON. SIR GEORGE, K.C.M.G., B.A., LL.M., Magill, S.A.
1930. OCKENDEN, G. P., Public School, Norton's Summit, S.A.
1913. *OSBORN, T. G. B., D.Sc., Professor of Botany, University, Oxford, England—**Council**, 1915-20, 1922-24; **President**, 1925-26; **Vice-President**, 1924-25, 1926-27.
1937. PARKIN, LESLIE W., B.Sc., c/o North Broken Hill Ltd., Box 20 C, Broken Hill, N.S.W.
1929. PAULL, ALEX. G., Eglinton Terrace, Mount Gambier.
1928. PHIPPS, IVAN F., Ph.D., B.Ag.Sc., Waite Agricultural Research Institute, Glen Osmond, S.A.
1926. *PIPER, C. S., M.Sc., Waite Agricultural Research Institute, Glen Osmond, S.A.
1936. PLATT, PROFESSOR A. E., M.D., B.S., D.T.M., D.T.H. (Syd.), Dip.Bact. (London), F.R.A.C.P., Adelaide Hospital, Adelaide, S.A.

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1925. *PRESCOTT, PROFESSOR J. A., D.Sc., A.I.C., Waite Agricultural Research Institute, Glen Osmond, S.A.—**Sir Joseph Verco Medal**, 1938; **Council**, 1927-30, 1935-; **Vice-President**, 1930-32; **President**, 1932-33.
1926. PRICE, A. GRENFELL, C.M.G., M.A., Litt.D., F.R.G.S., St. Mark's College, North Adelaide.
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1933. SCHNEIDER, M., M.B., B.S., 175 North Terrace, Adelaide.
1924. *SEGNIT, R. W., M.A., B.Sc., Assistant Government Geologist, Flinders Street, Adelaide—**Secretary**, 1930-35; **Council**, 1937-38; **Vice-President**, 1938-39; **President**, 1939-.
1925. *SHEARD, HAROLD, Nuriootpa, S.A.
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1923. *TINDALE, N. B., B.Sc., South Australian Museum, Adelaide **Secretary**, 1935-36.
1935. TRIGG, F., Government Printing Office, Adelaide, S.A.
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1912. *WARD, L. KEITH, B.A., B.E., D.Sc., Govt. Geologist, Flinders Street, Adelaide—**Council**, 1924-27, 1933-35; **President**, 1928-30; **Vice-President**, 1927-28.
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1936. WATERHOUSE, MISS LORNA M., 35 King Street, Brighton, S.A.
1939. WEEDING, REV. B. J., Eudunda.
1931. WILSON, C. E. C., M.B., B.S., "Woodfield," Fisher Street, Fullarton, Adelaide.
1938. *WILSON, J. O., Nutrition Laboratory, University, Adelaide.
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1930. *WOMERSLEY, H., F.R.E.S., A.I.L.S., Museum, Adelaide—**Secretary**, 1936-37; **Editor**, 1937-.
1923. *WOOD, J. G., D.Sc., Ph.D., Professor of Botany, University, Adelaide **Council**, 1938-.

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